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Encina Llamas, Gerard; Epp, Bastian; M. Harte, James; Dau, Torsten

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Evaluation of peripheral compression and auditory nerve fiber intensity coding using Auditory Steady-State Responses (ASSR)

Gerard Encina Llamas

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| Torsten Dau, | Technical University of Denmark |

27th of August, 2015

International Symposium on Auditory and Audiological Research (ISAAR) , Nyborg (Denmark)

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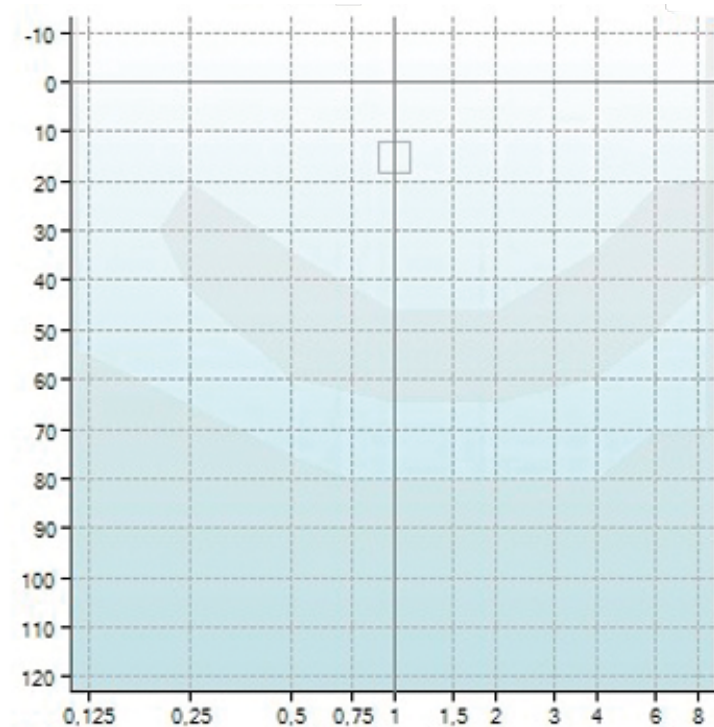
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The need for SUPRA-threshold evaluation

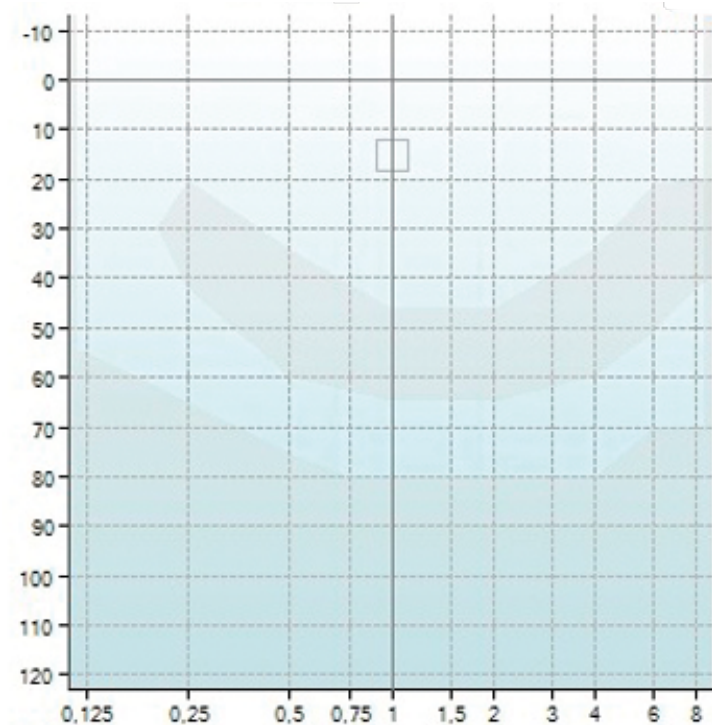
Humans in clinics:



5-10% of patients self-report hearing difficulties while showing normal audiograms

Saunders and Haggard (1989, 1992); Kumar *et al.* (2007); Hind *et al.* (2011)

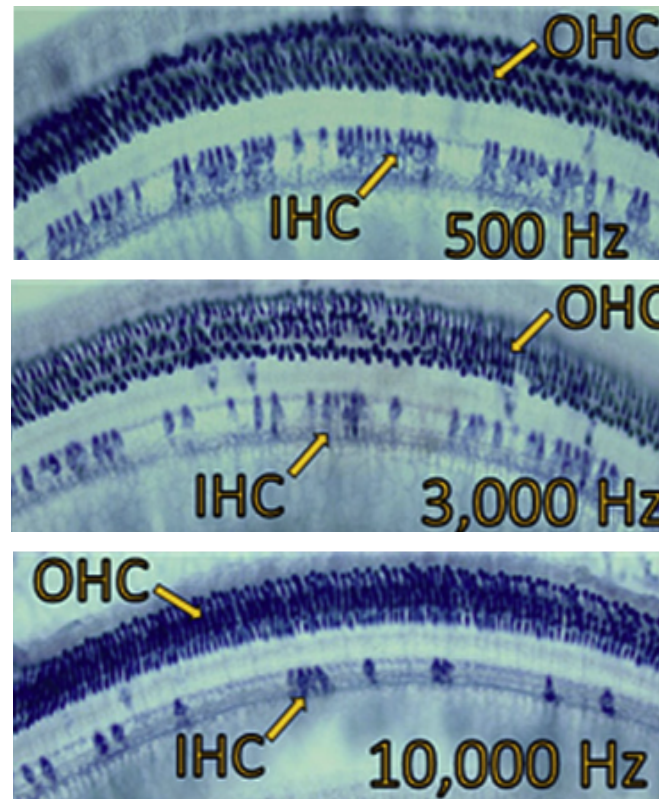
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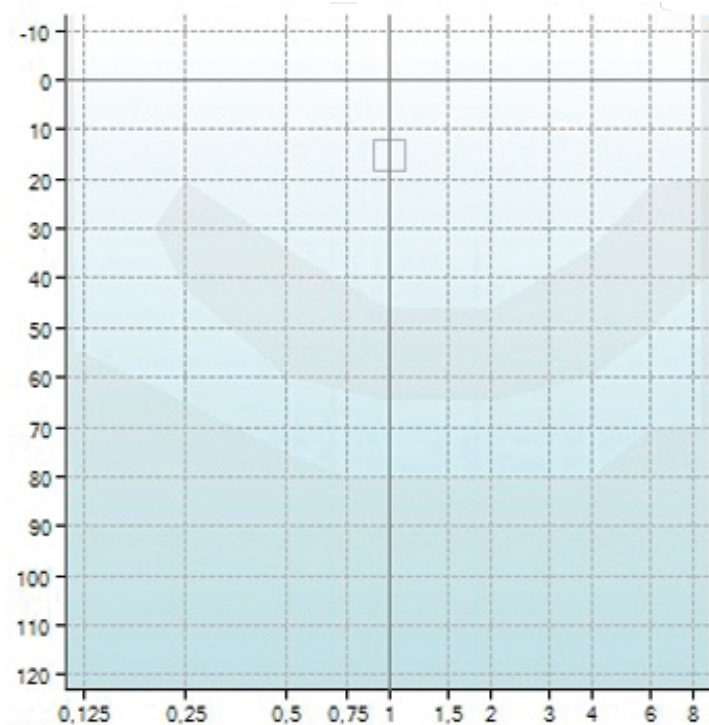
Physiological studies in animals:



Normal behavioral thresholds with **80% loss** of **IHCs**

Lobarinas *et al.* (2013)

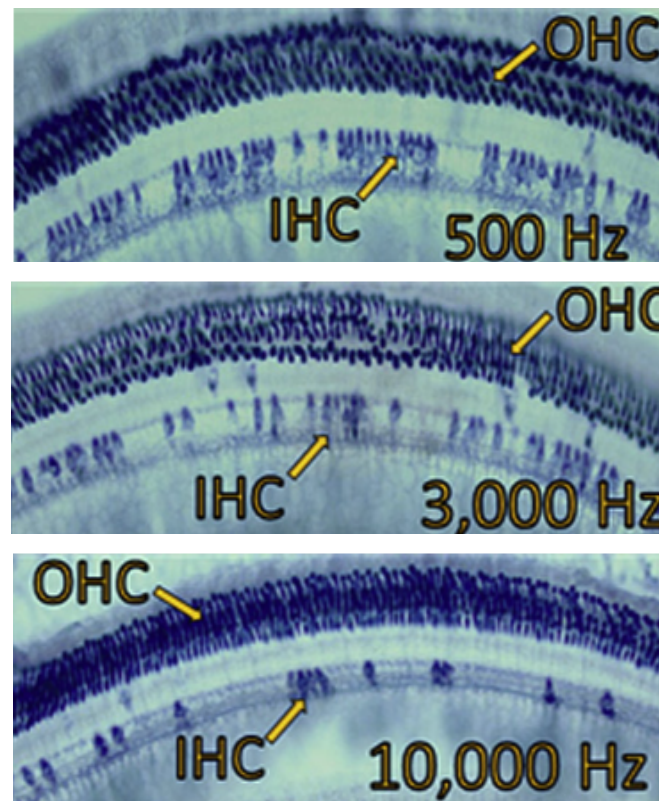
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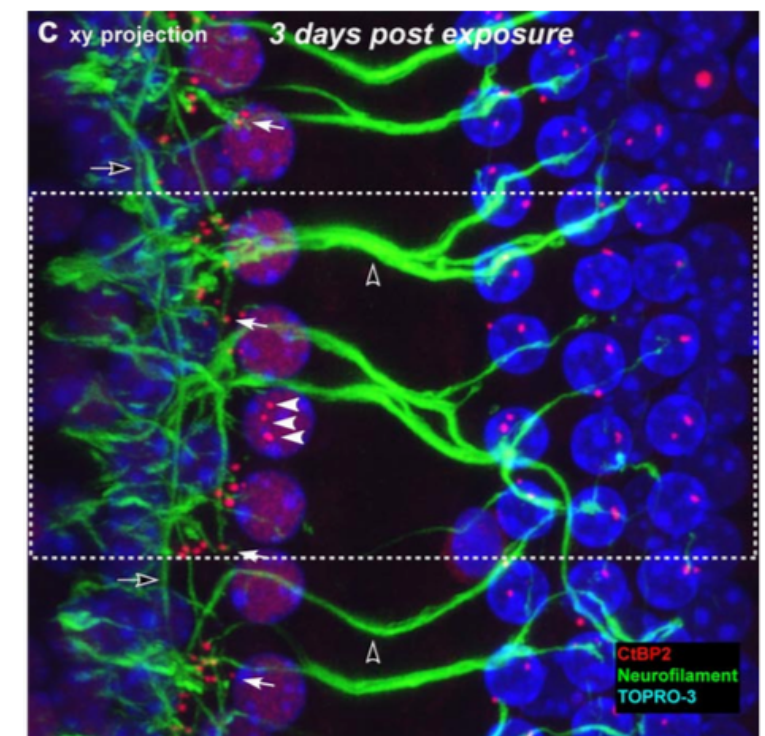
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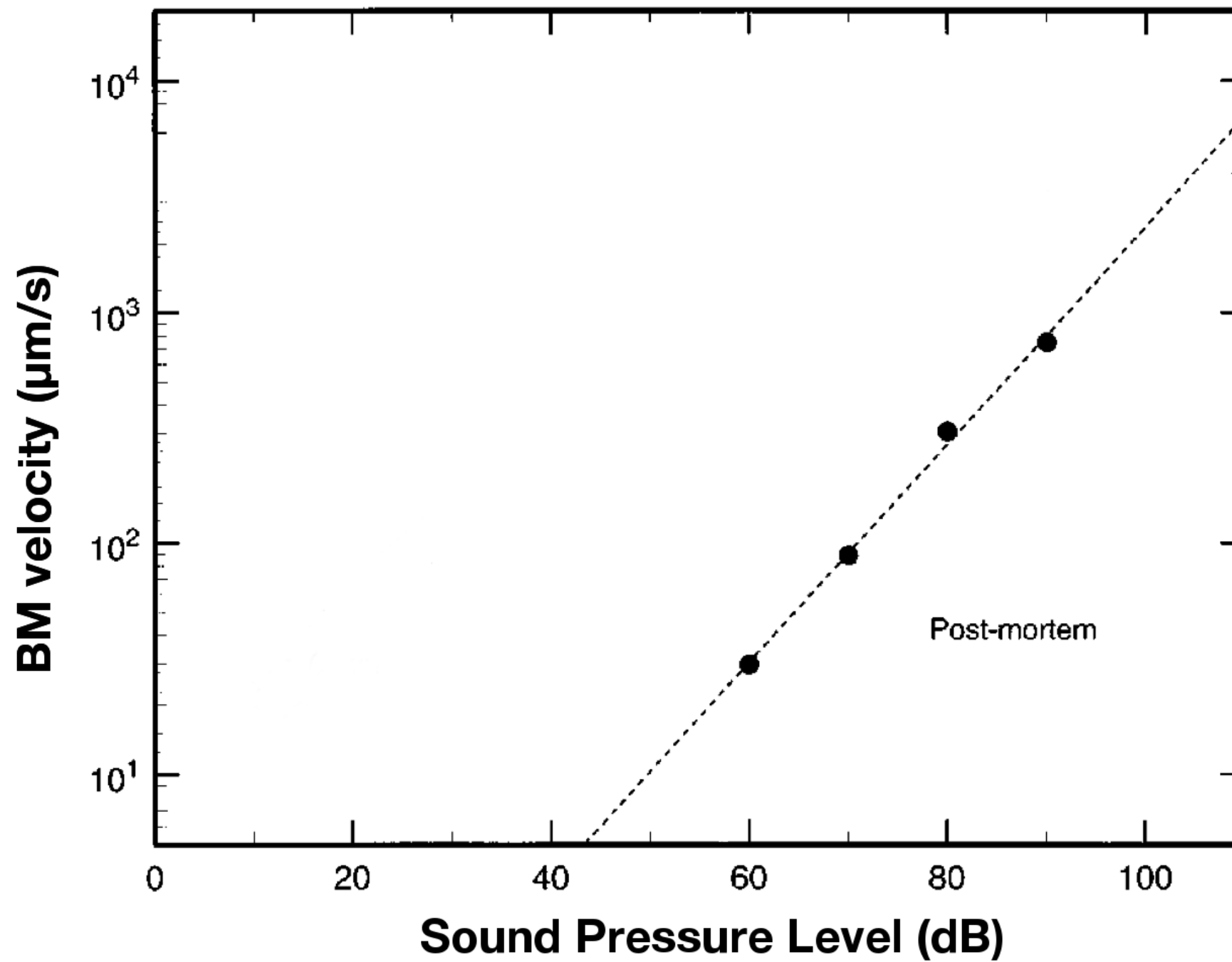


Auditory nerve fibers (ANF) **deafferentation** is **not reflected** as permanent threshold elevation

Kujawa and Liberman (2009), Lin *et al.* (2011), Furman *et al.* (2013)

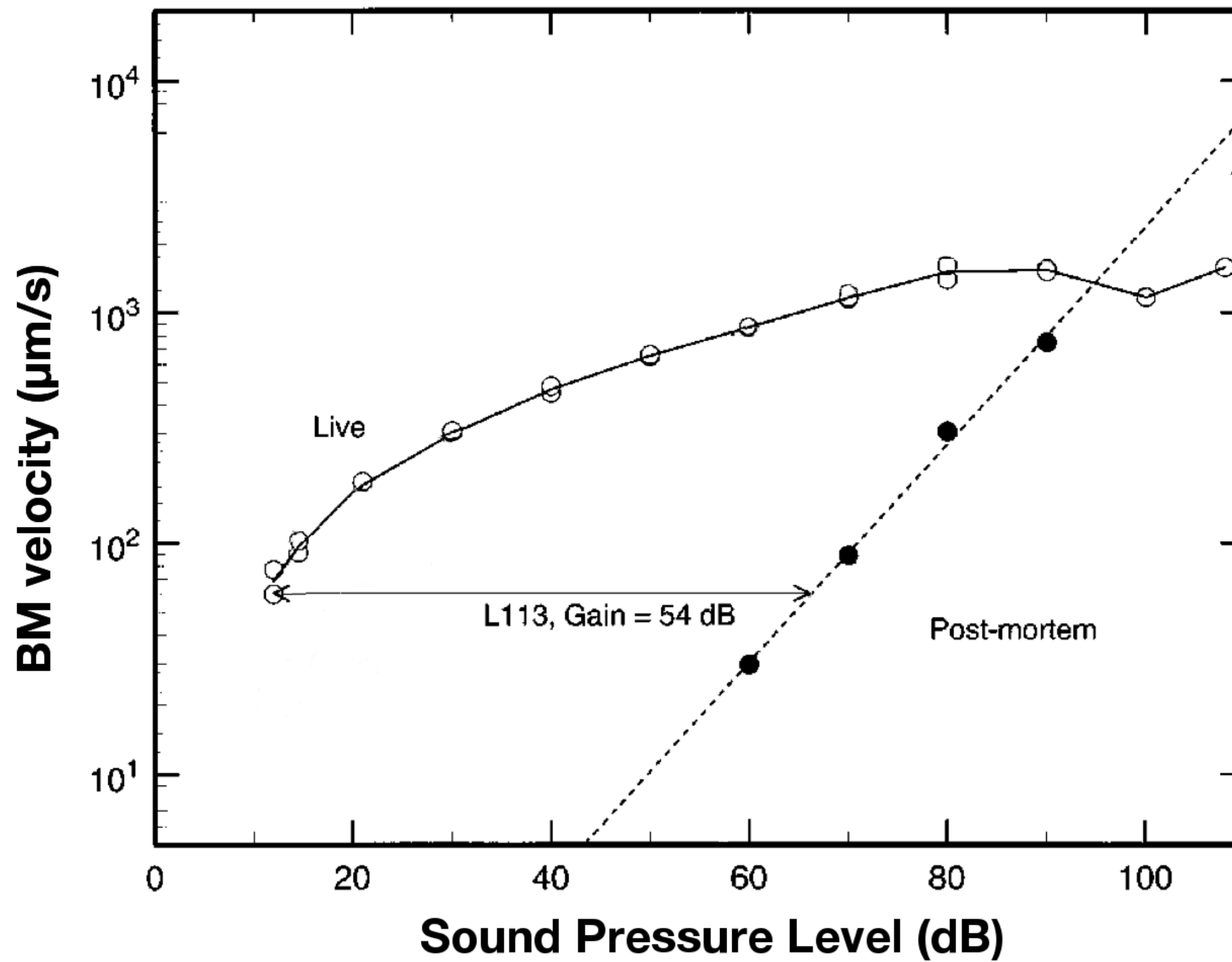
Compression: Animal data

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Ruggero *et al.* (1997)

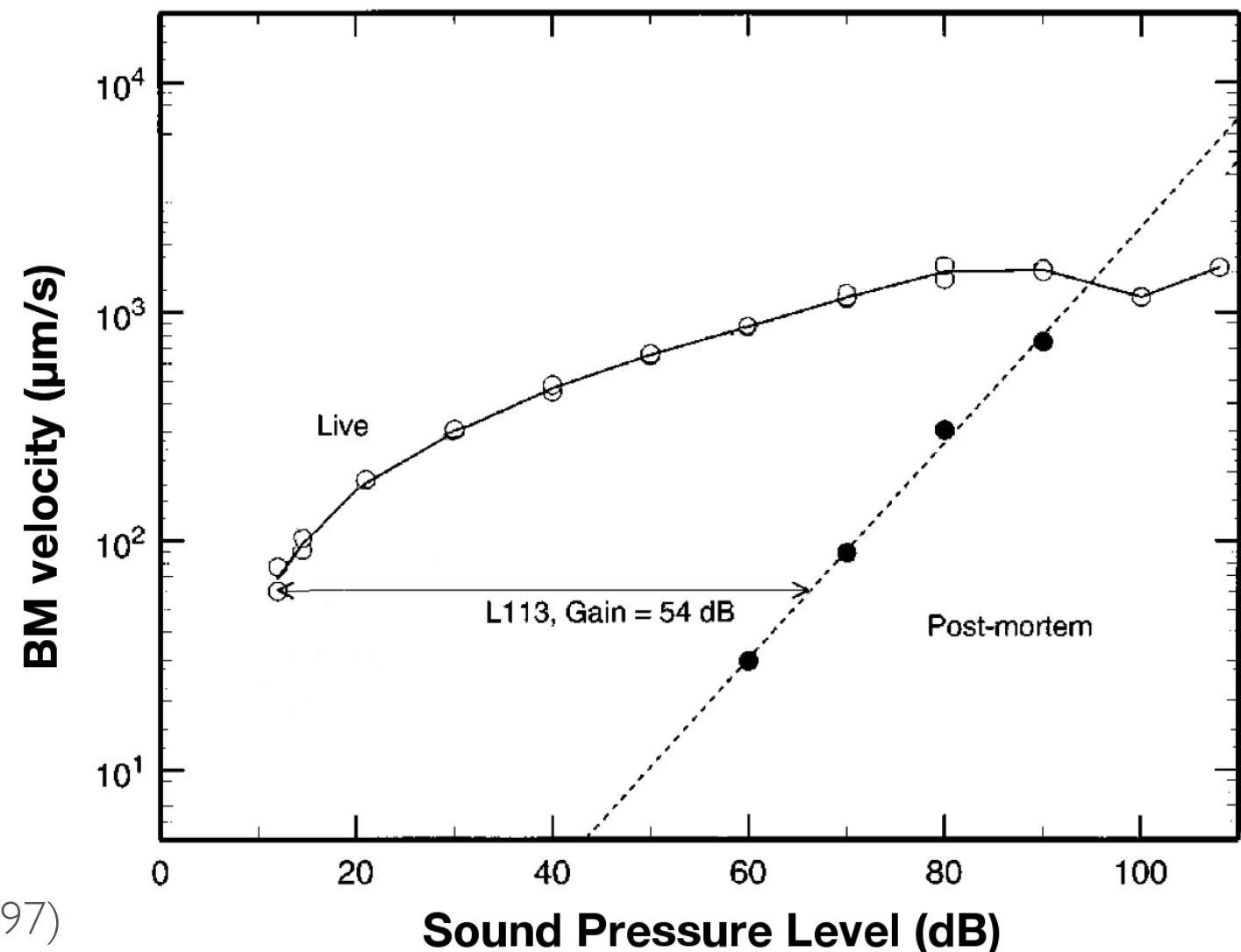
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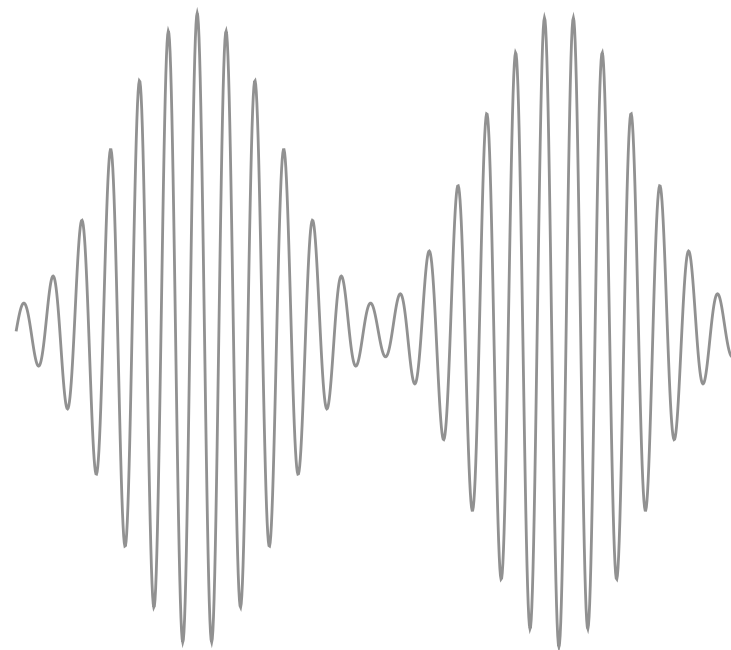
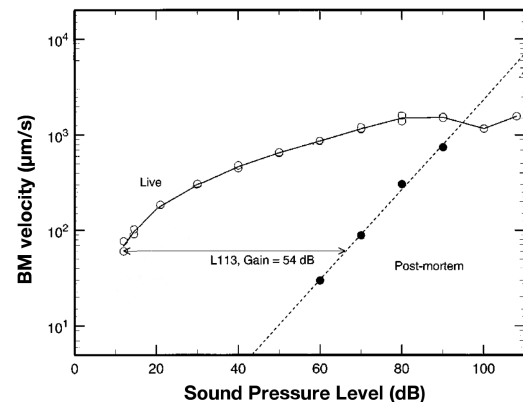
Compression: Auditory Steady-State Responses

- The **healthy cochlea** shows a **compressive growth** as a function of stimulation level.



Ruggero *et al.* (1997)

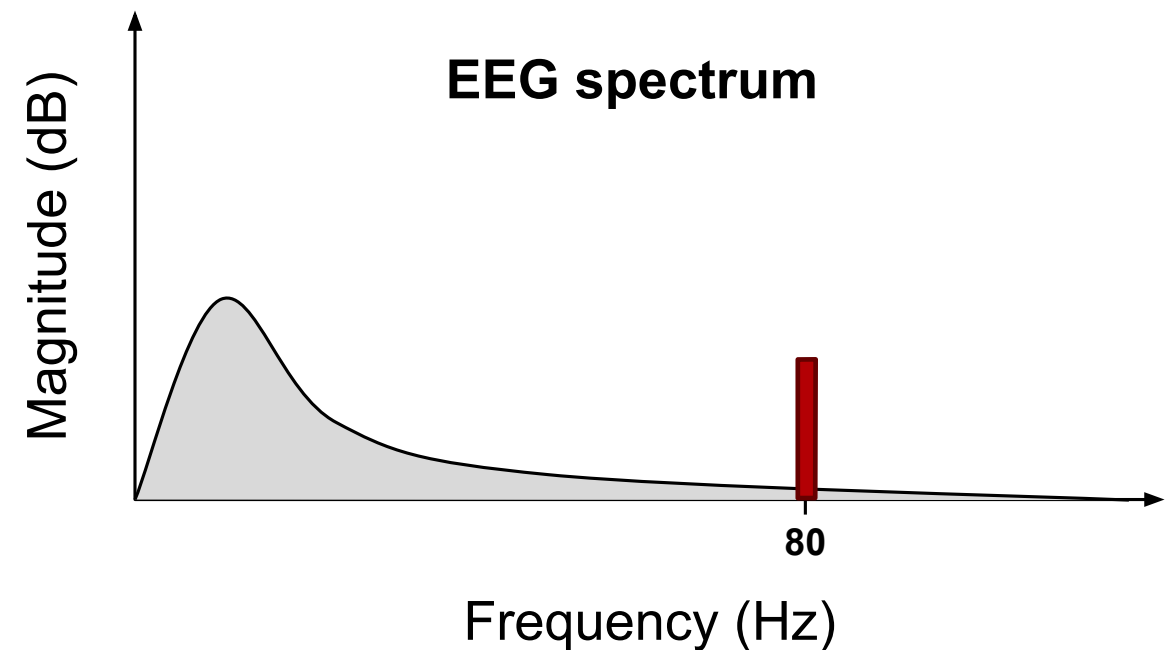
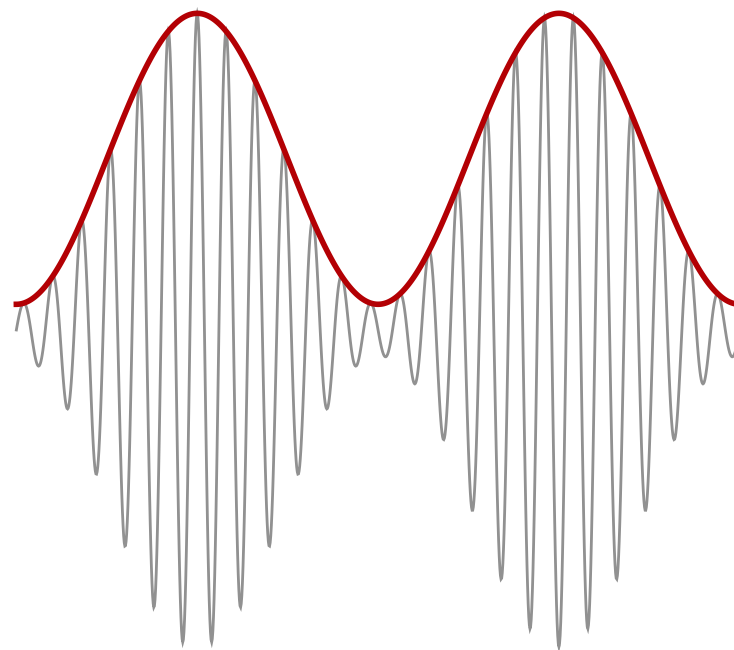
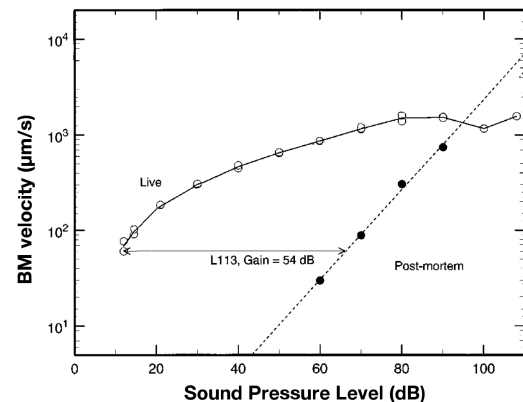
- The **healthy cochlea** shows a **compressive growth** as a function of stimulation level.
- ASSR reflect **envelope** coding.



$$A \cdot \sin(2\pi f_c t) \cdot \left[\frac{1 + m \cdot \sin(2\pi f_m t)}{2} \right]$$

1 kHz @ 80 Hz
m = 85%

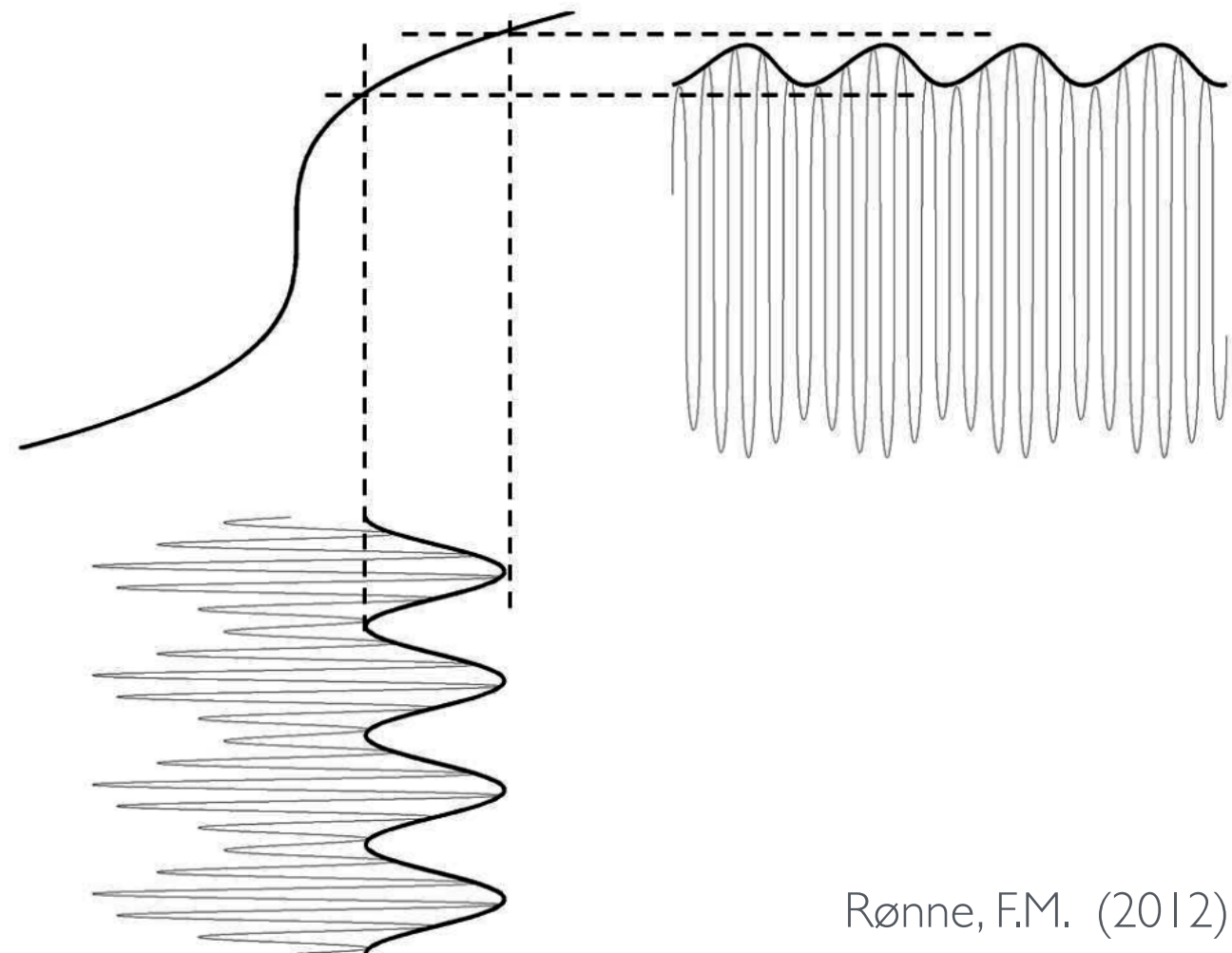
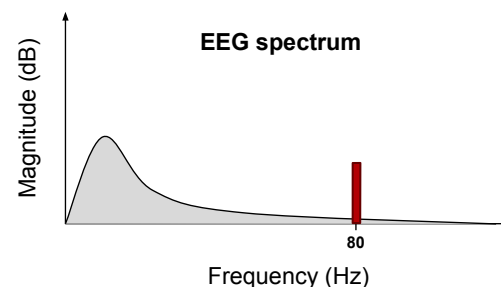
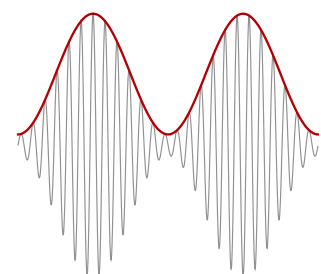
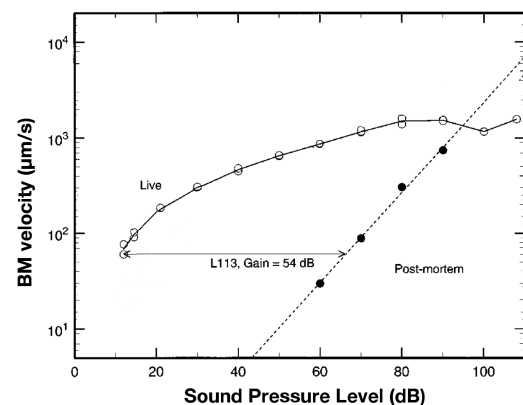
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- The **healthy cochlea** shows a **compressive growth** as a function of stimulation level.
- ASSR reflect **envelope** coding.
- Compression **affects** to the **envelope**, hence it should affect to **ASSR**.

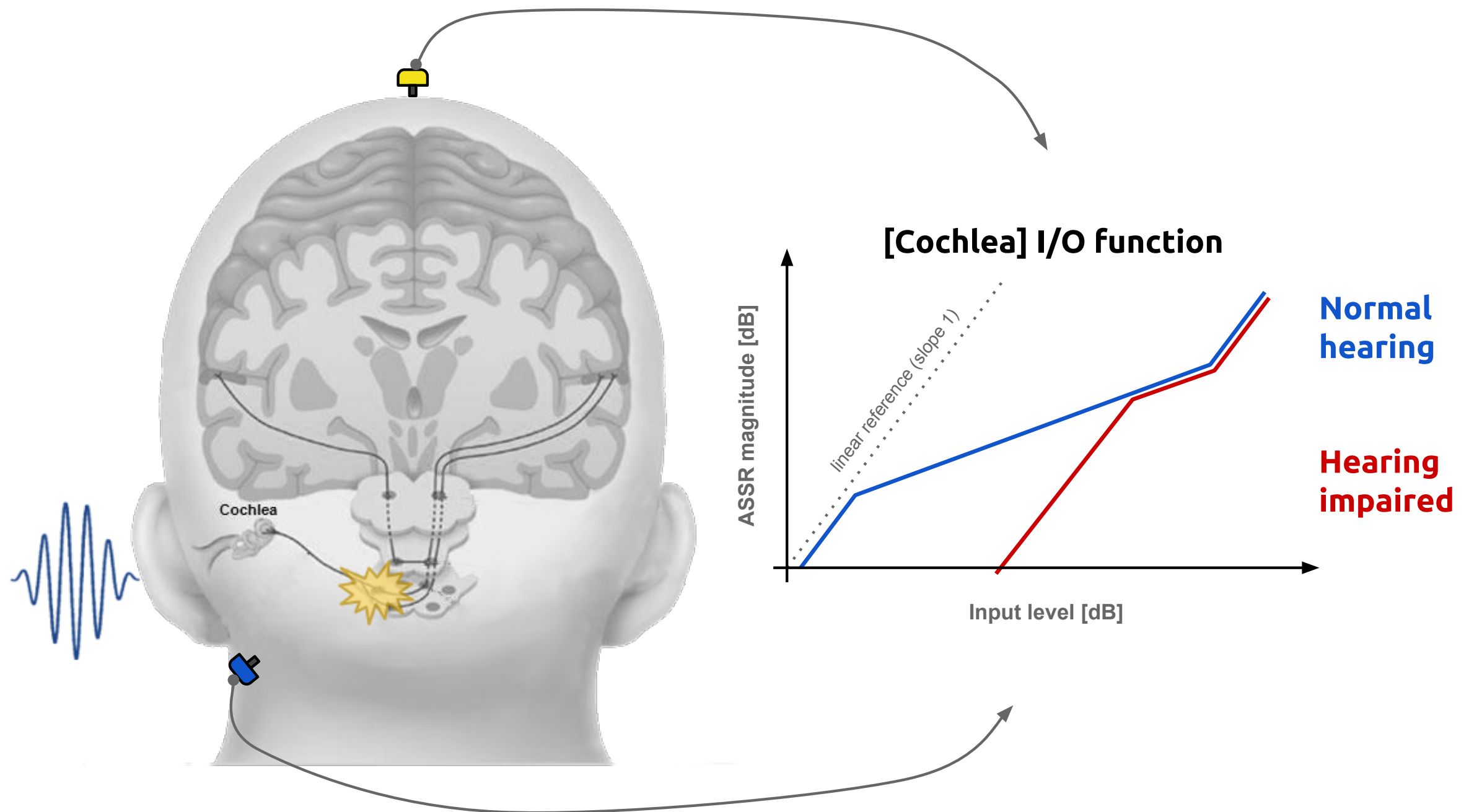


Rønne, F.M. (2012)

Research question

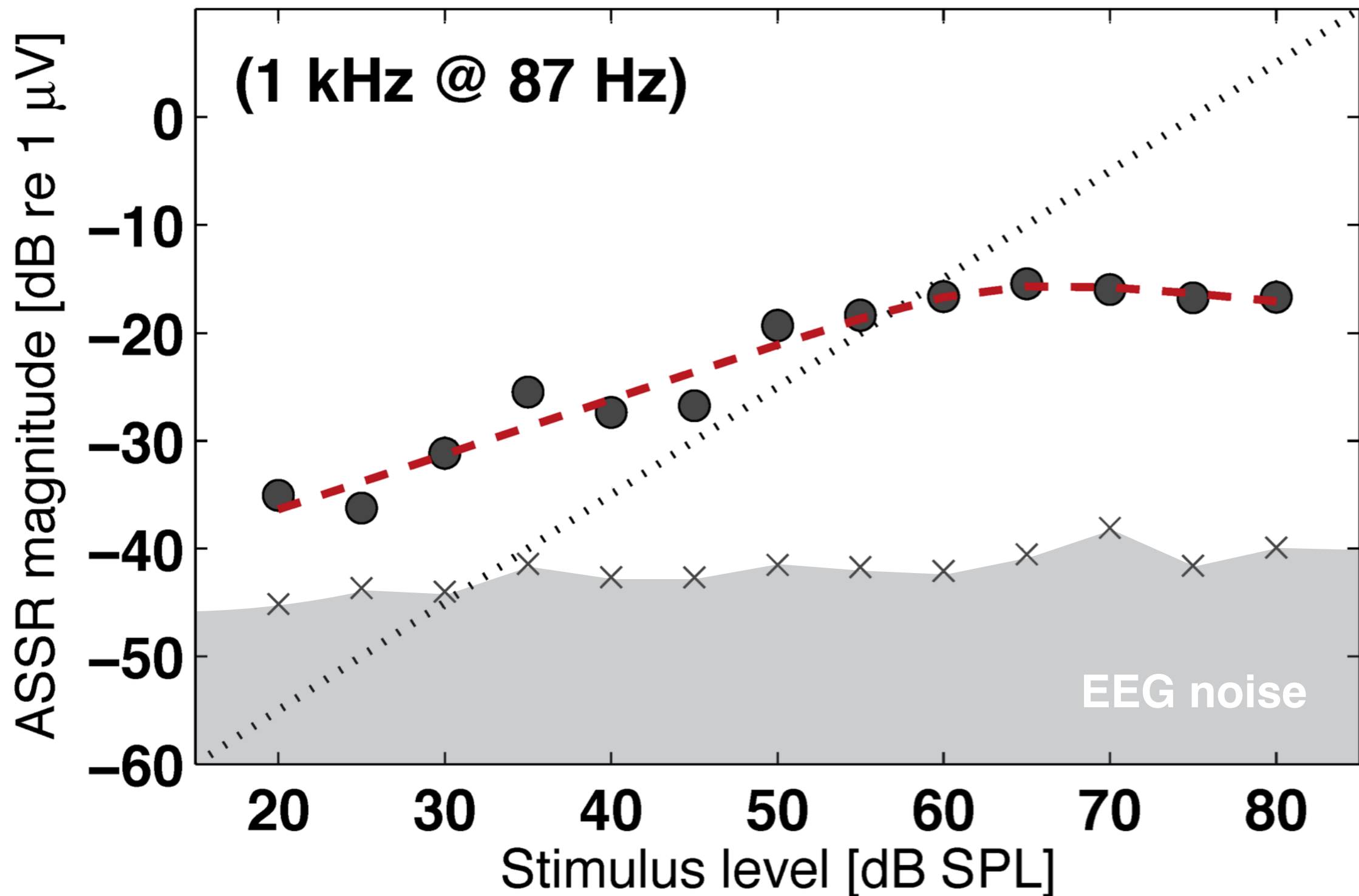
Research question

Is it possible to estimate **peripheral compression** using **ASSR**?



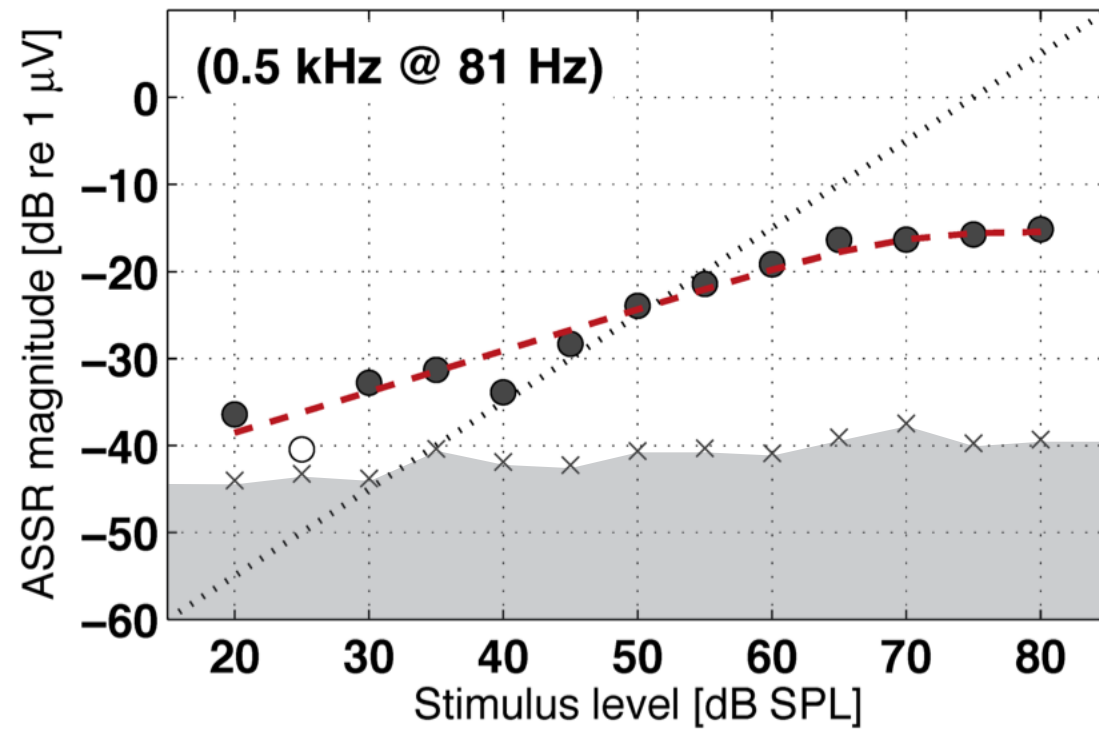
Results: A representative NH subject (N=13)

B

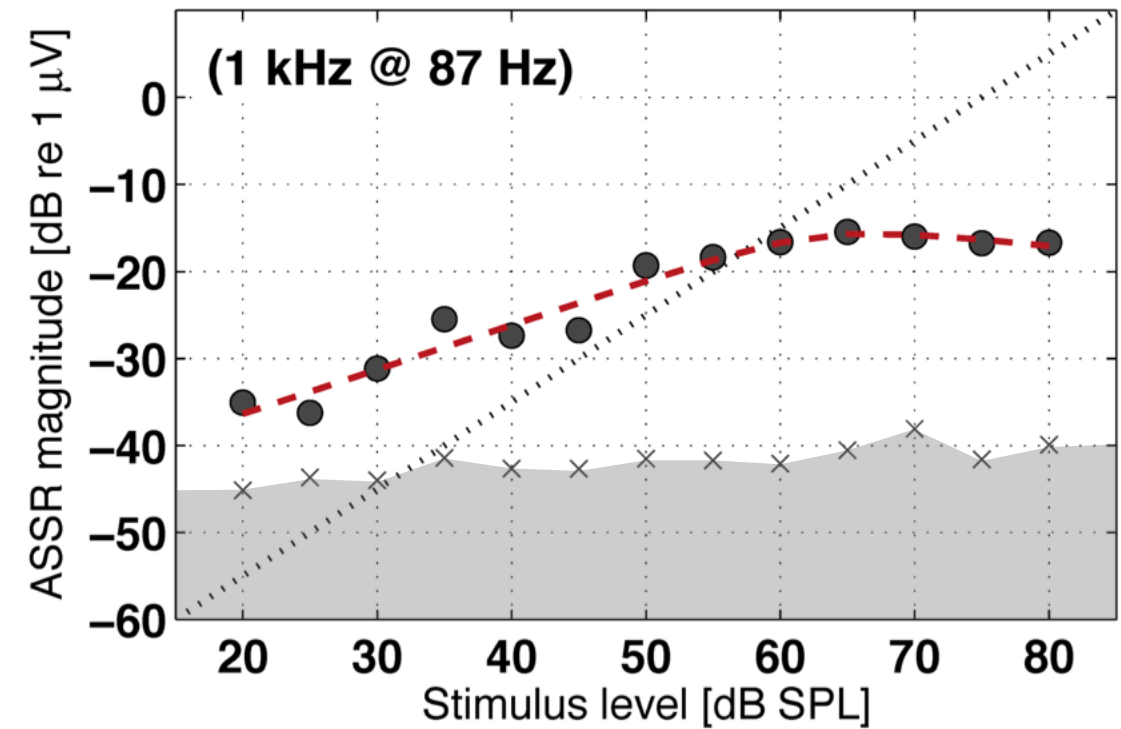


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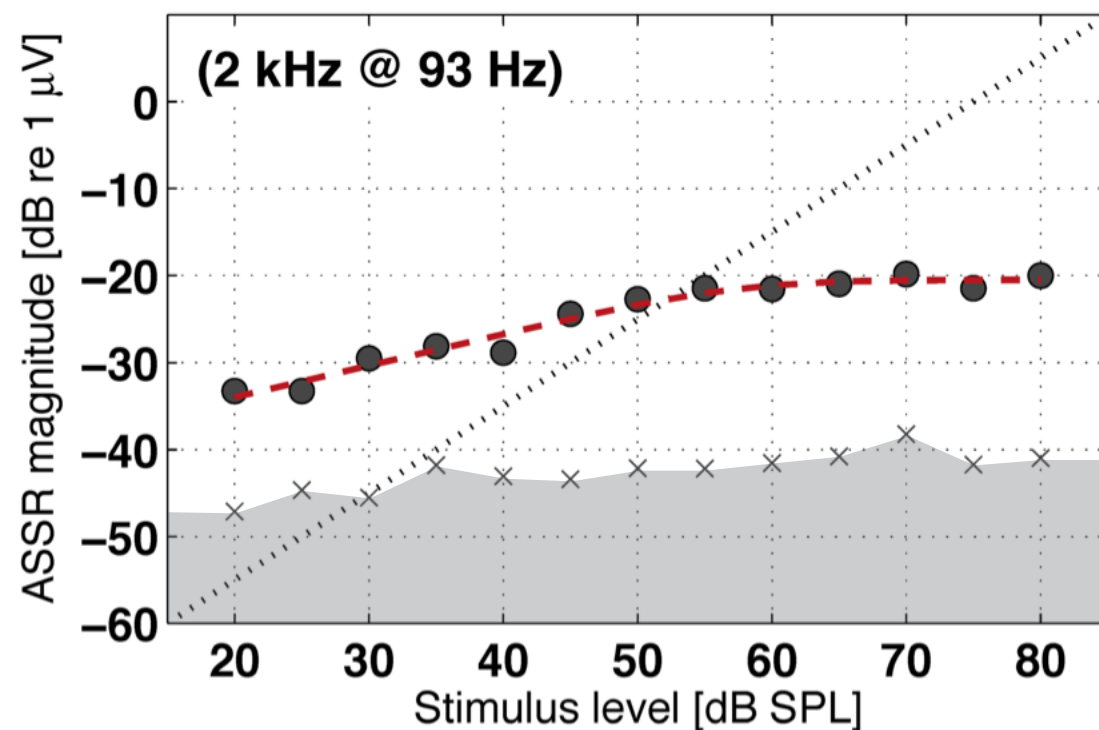
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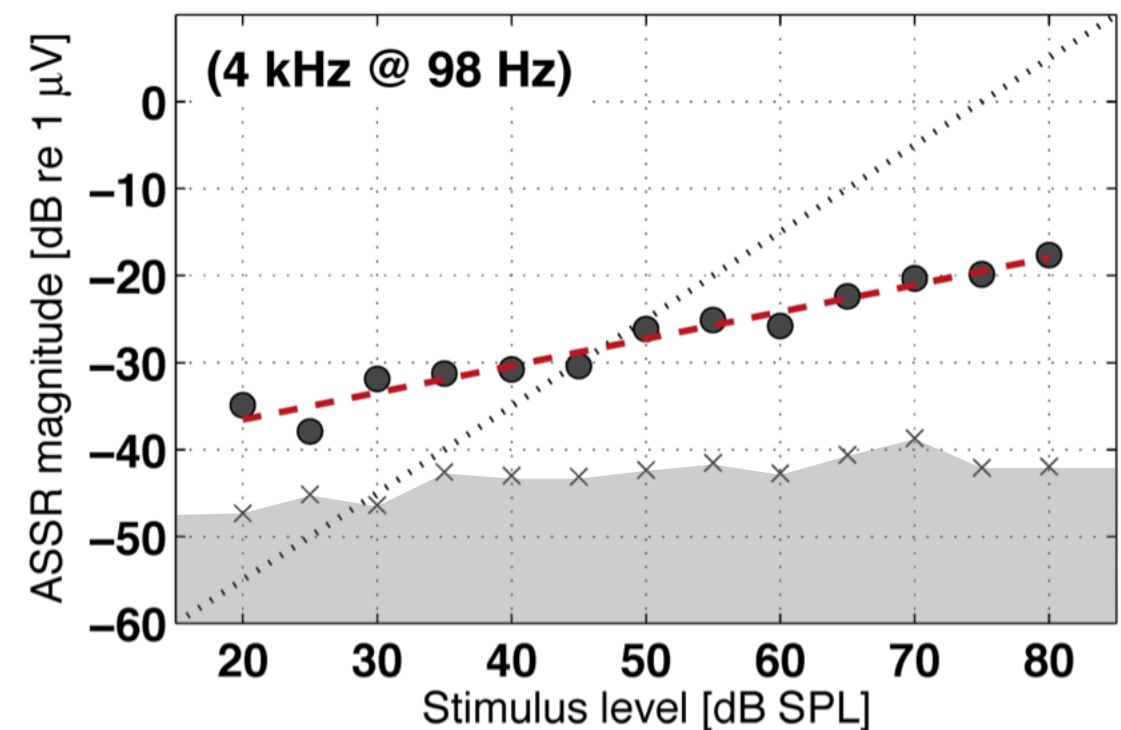
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C

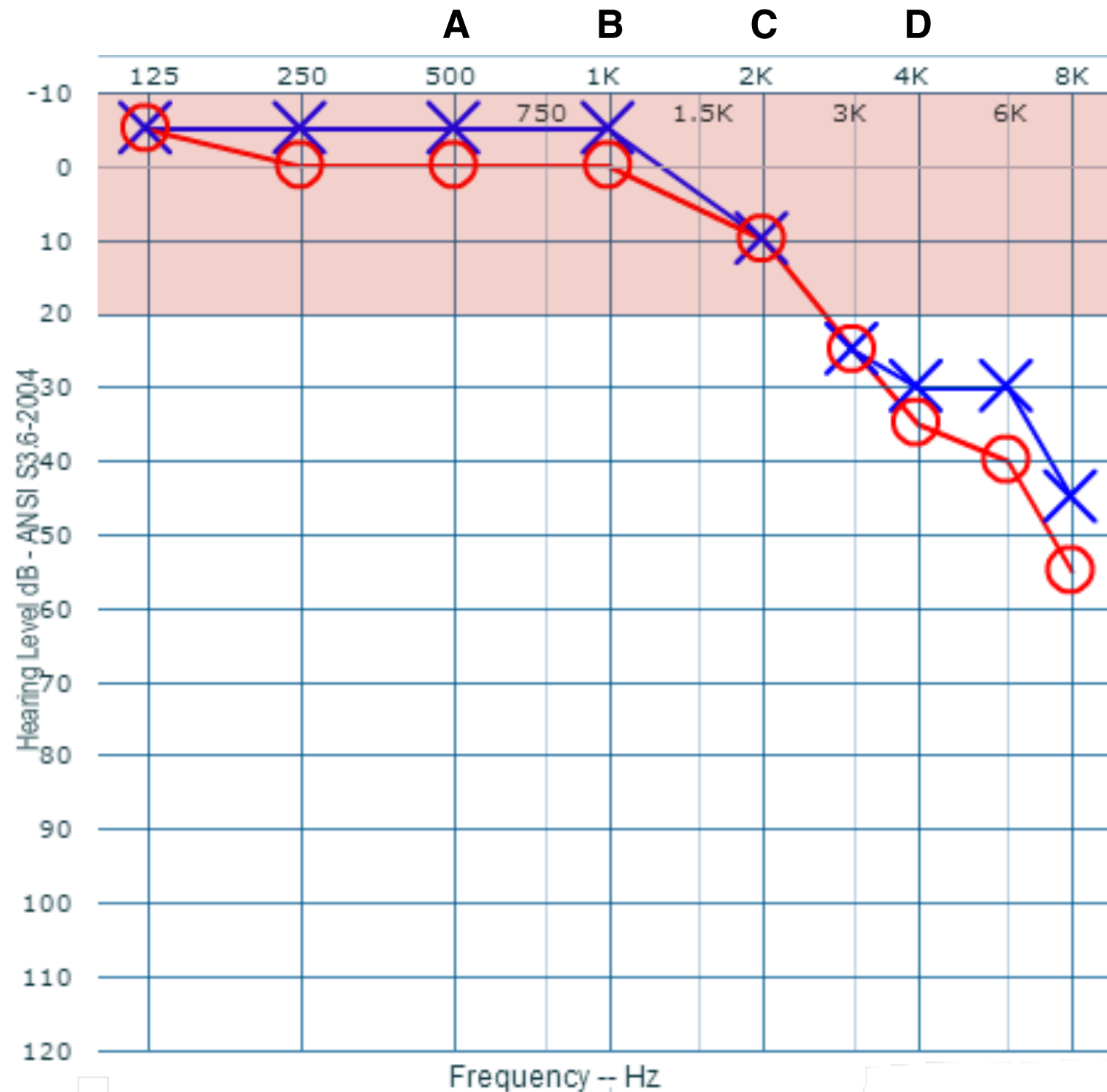


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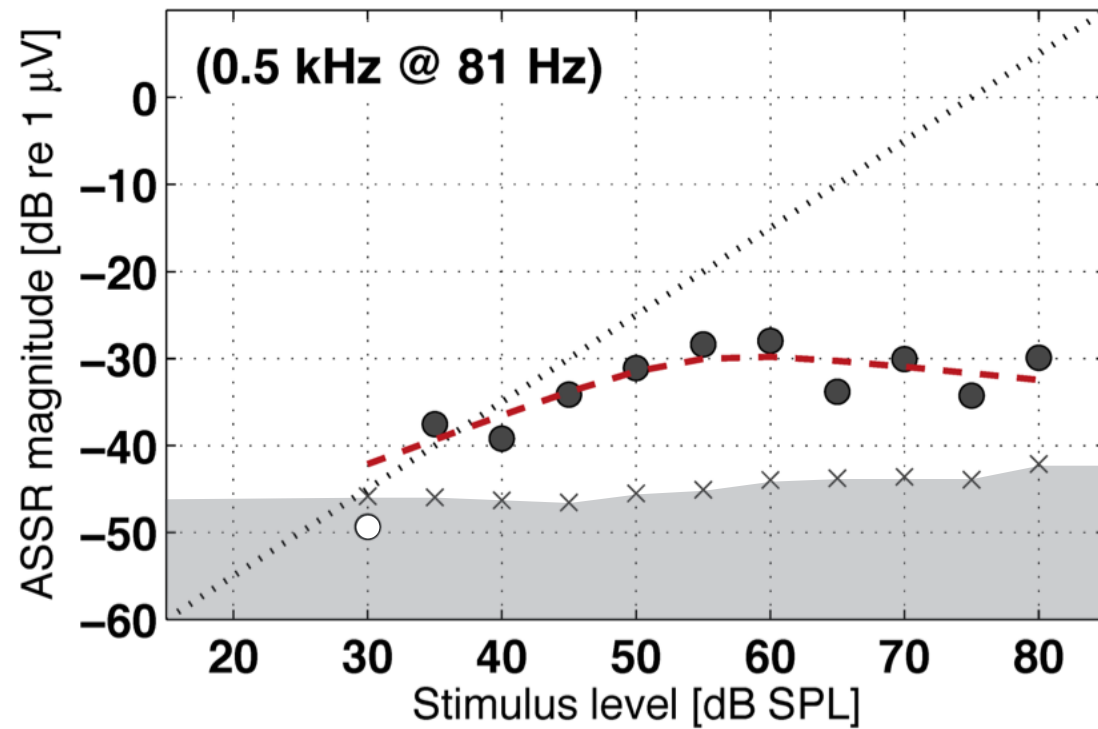
Results: A representative HI subject (N=7)

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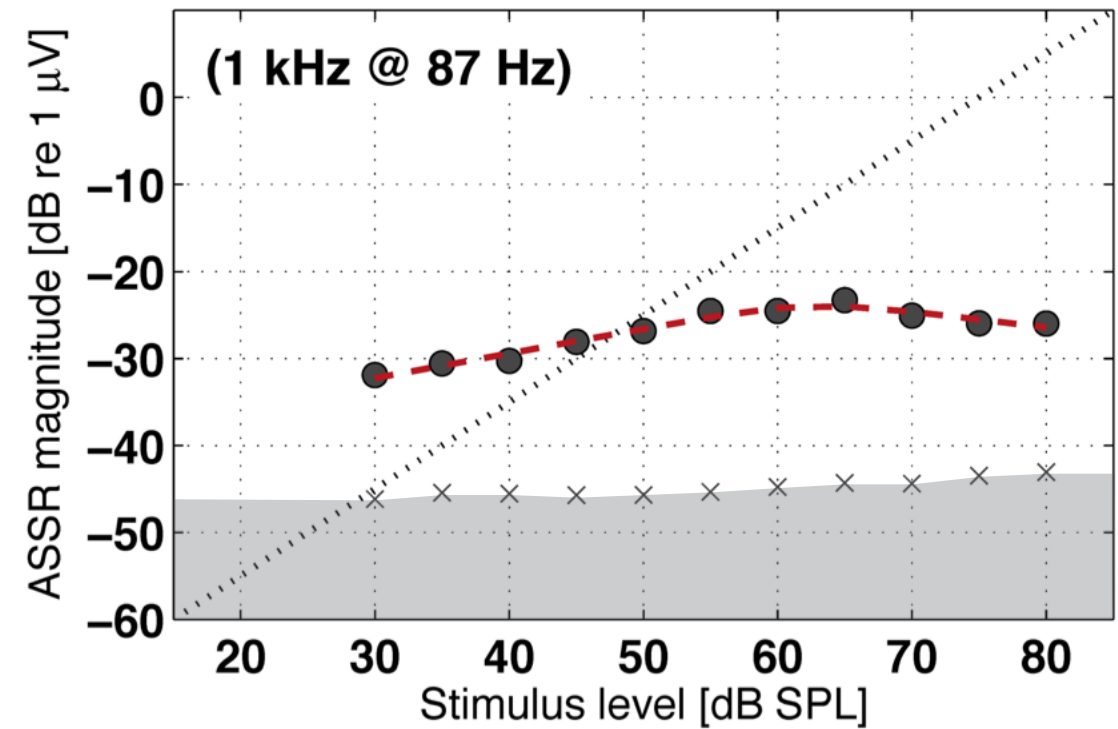


Results: A representative HI subject (N=7)

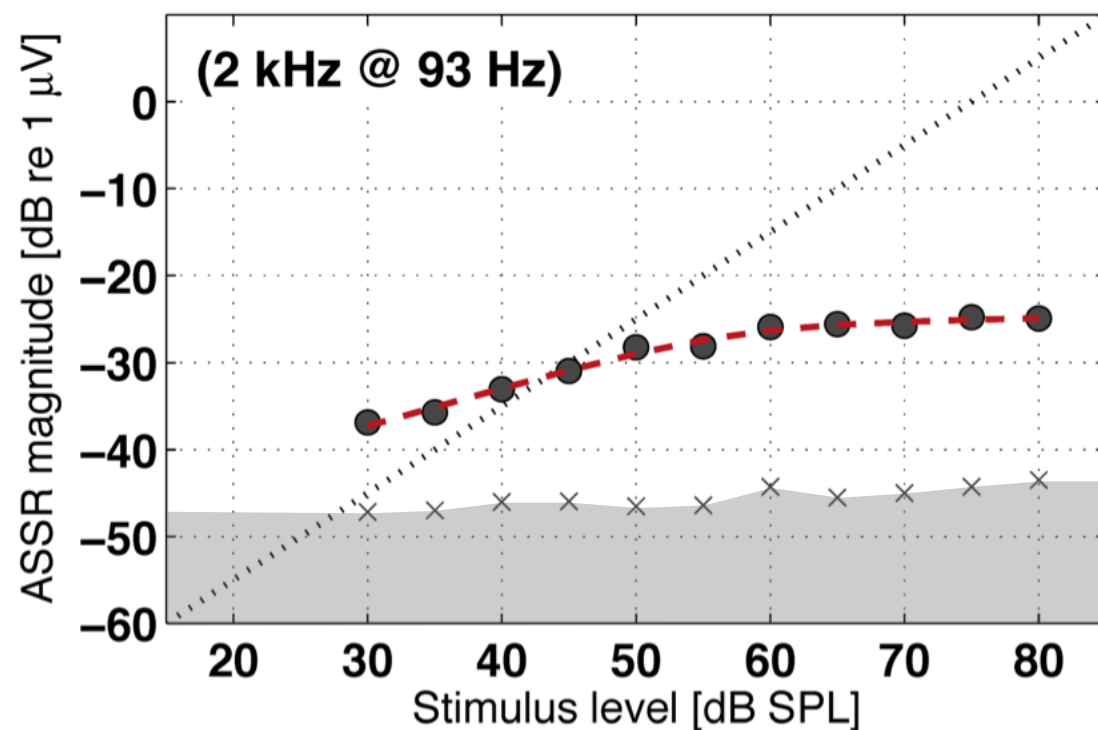
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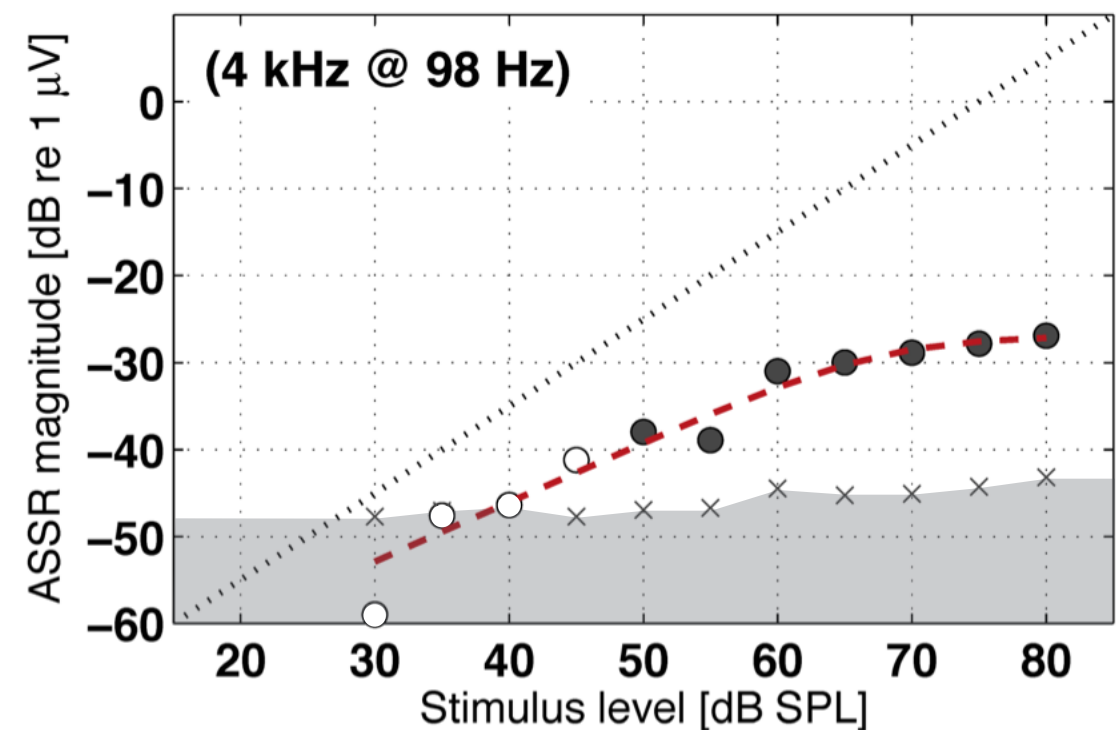
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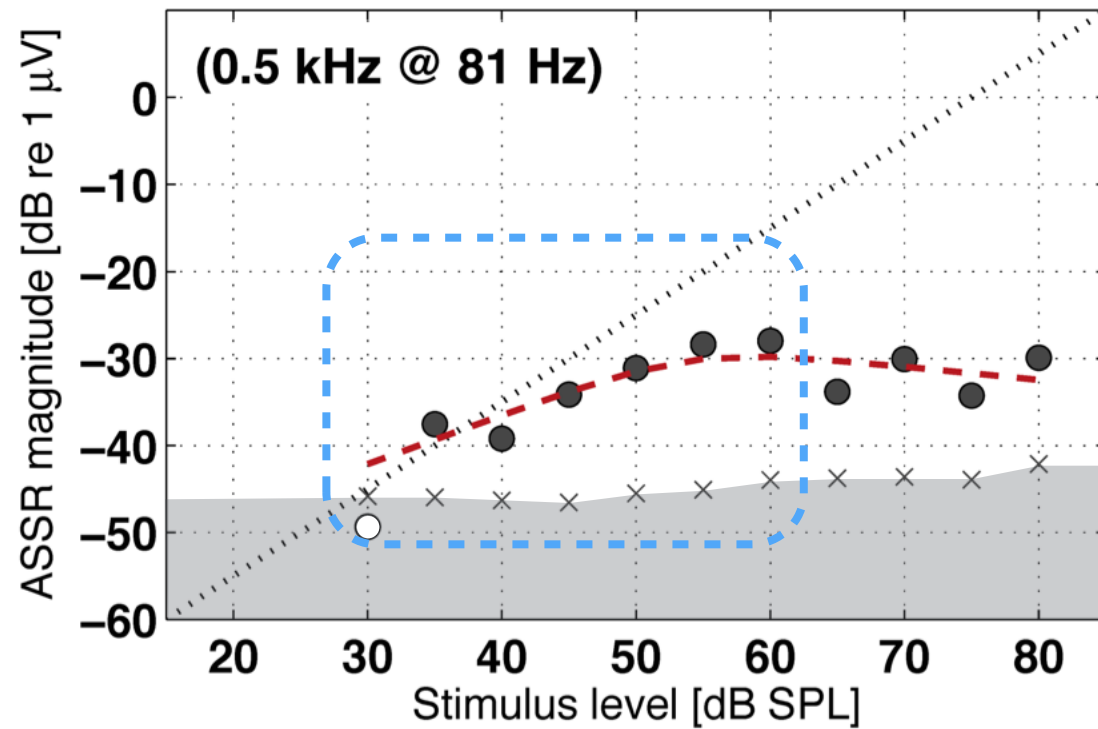


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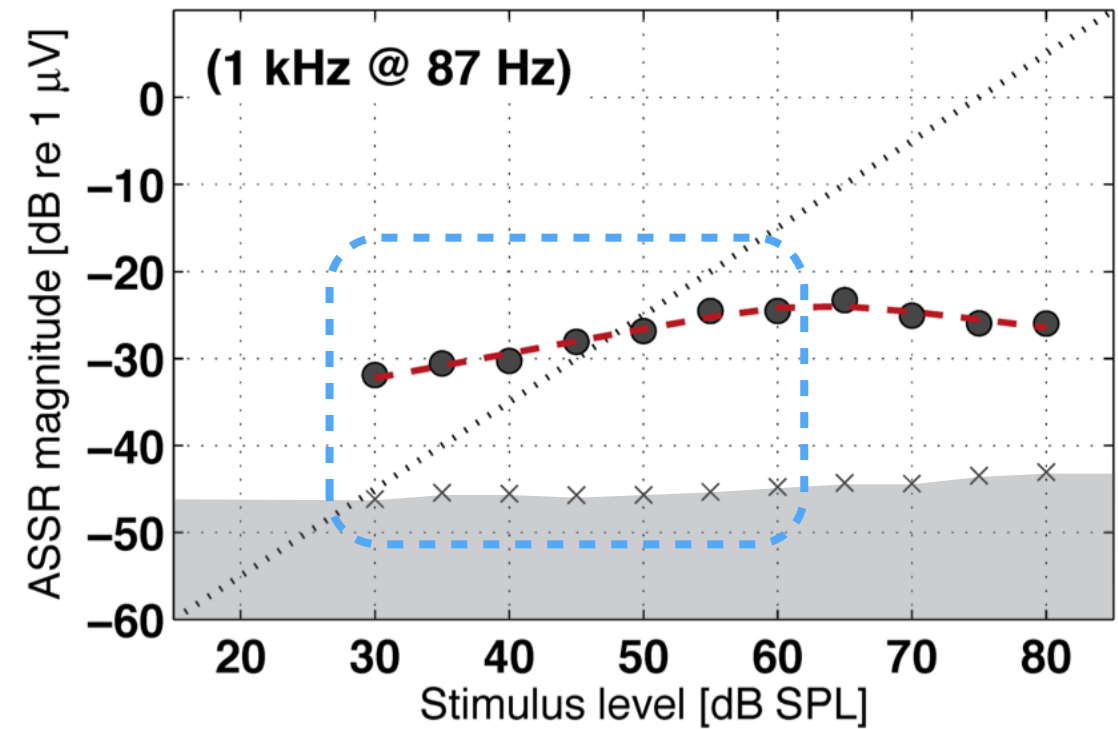


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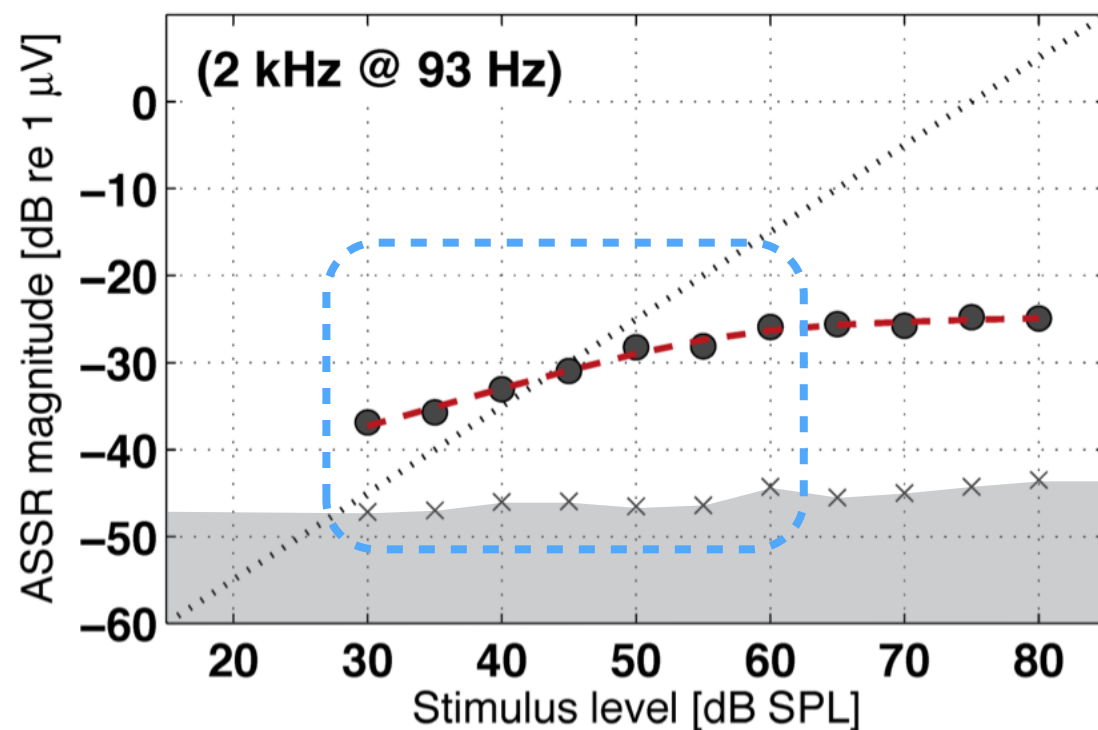
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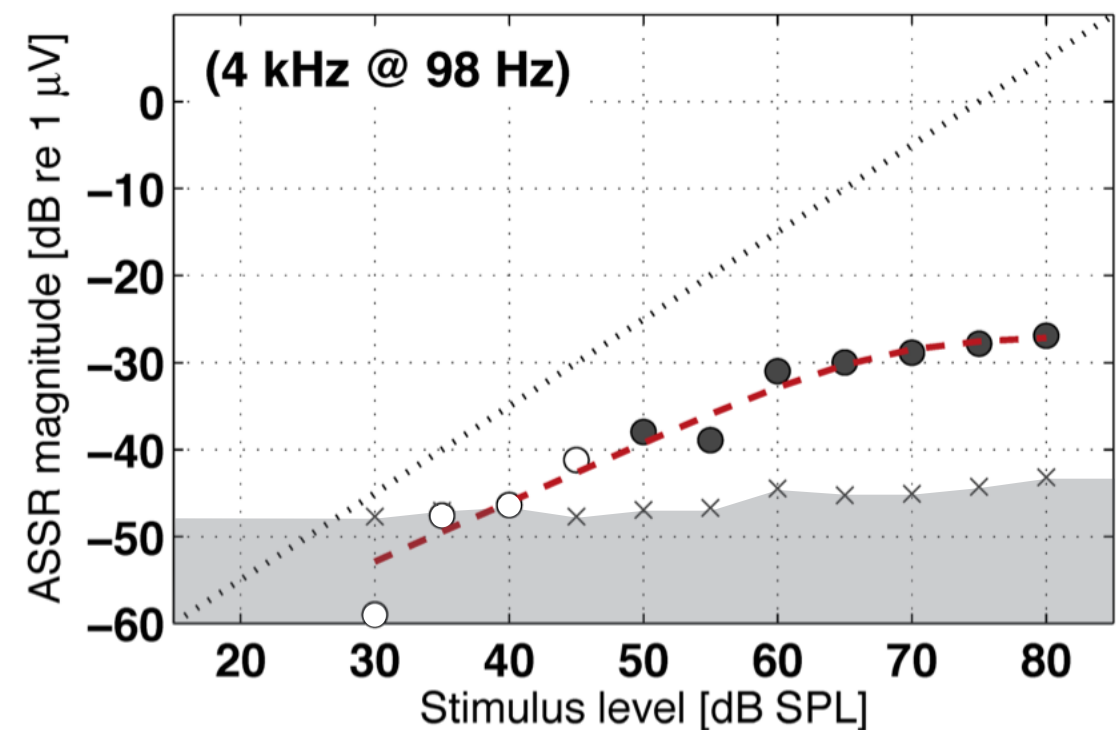
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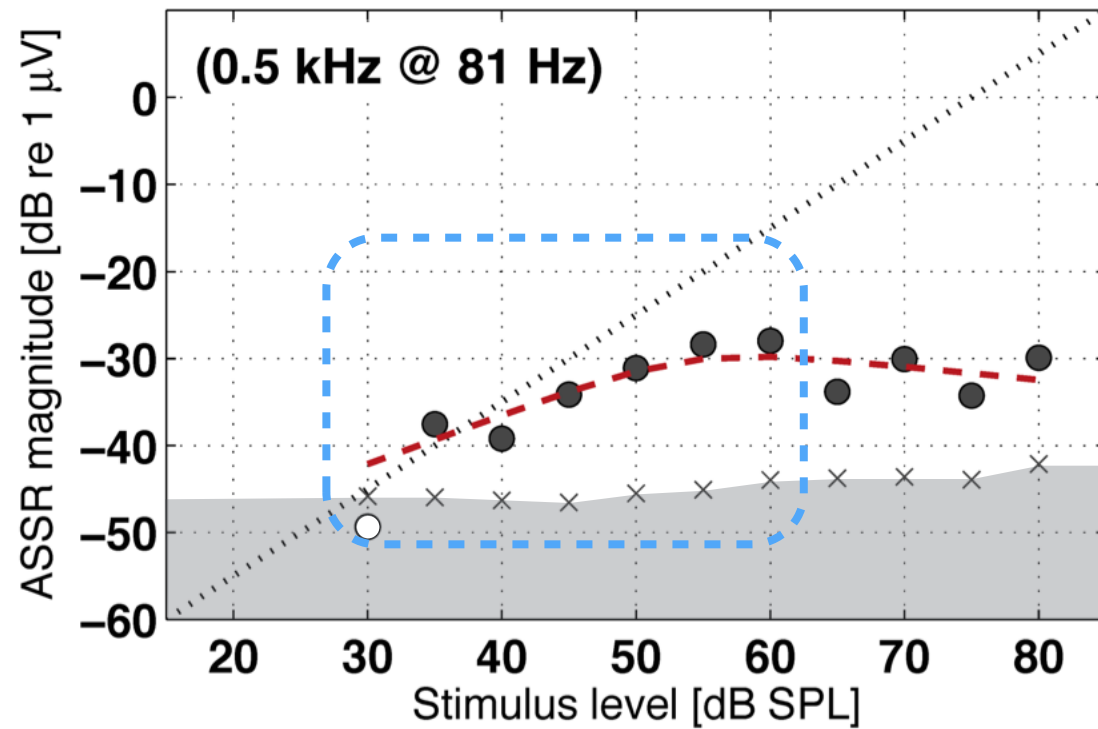


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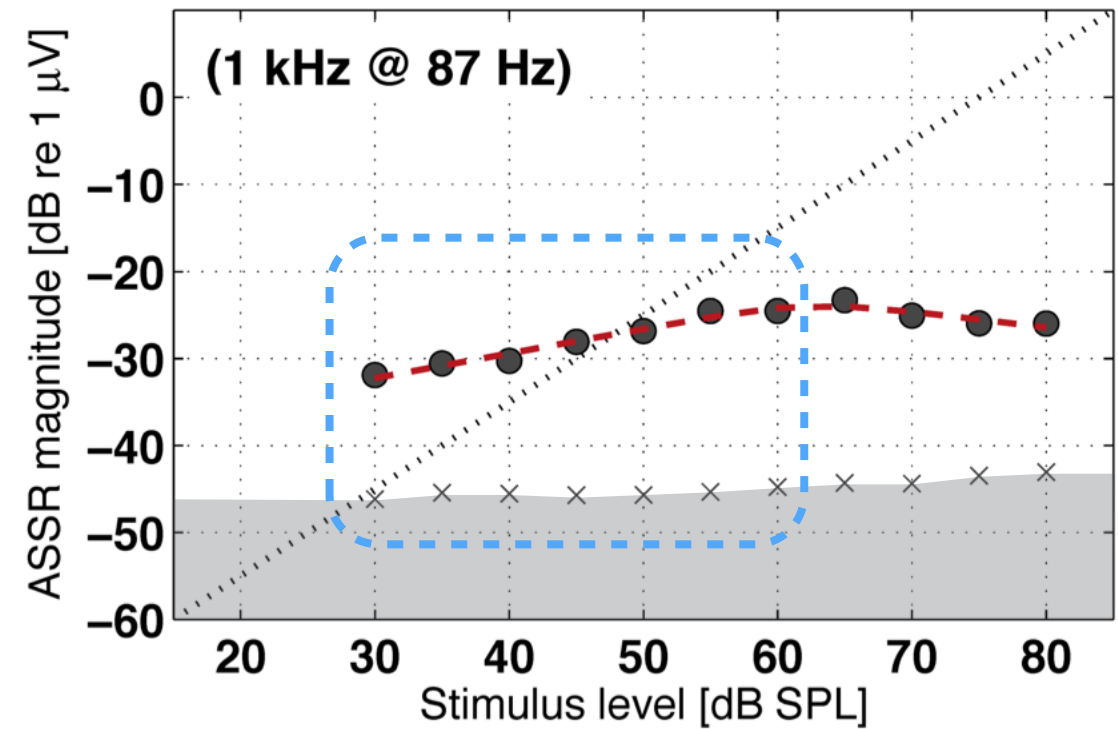


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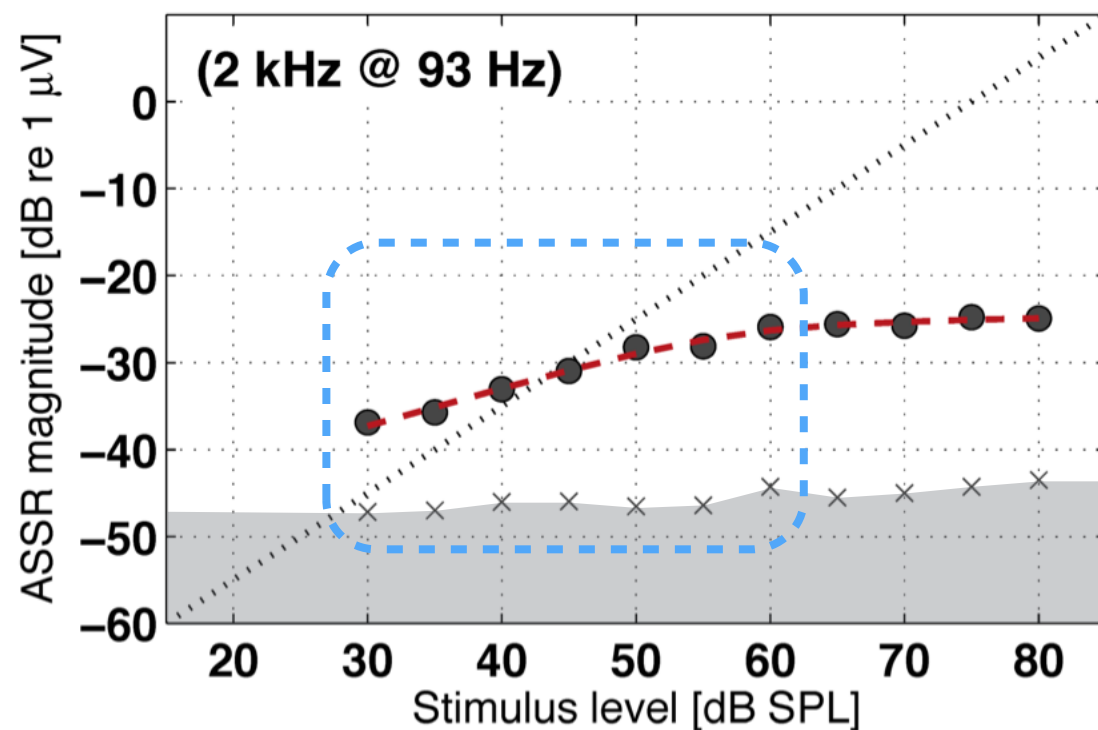
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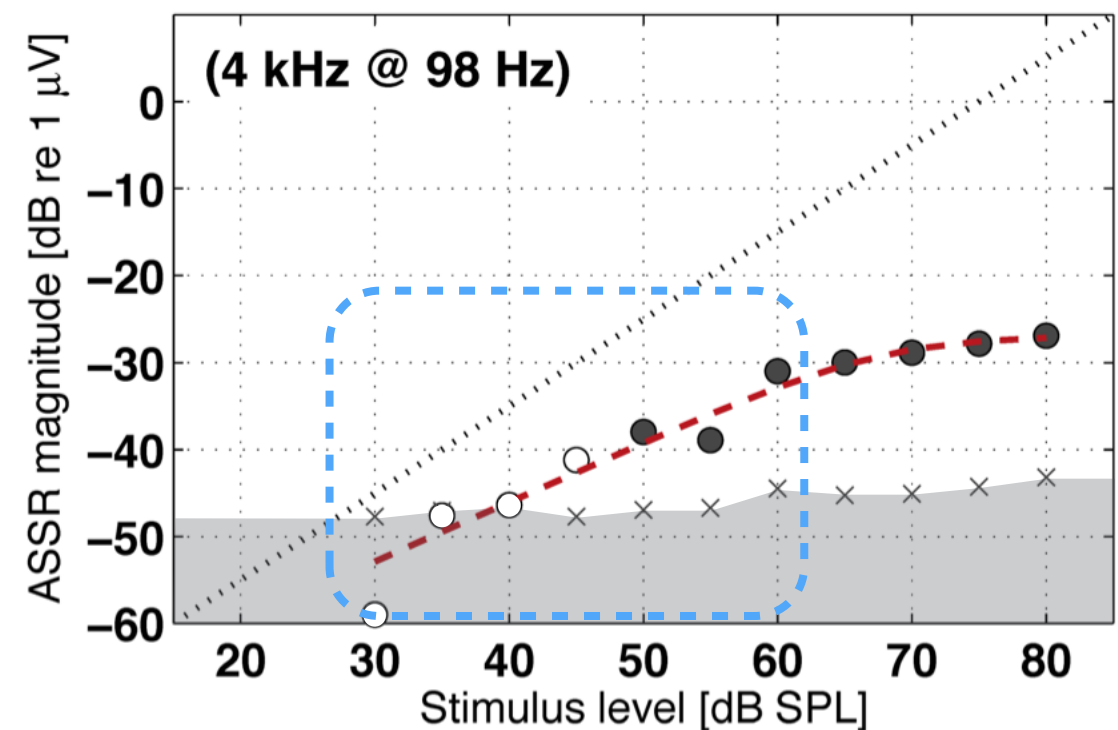
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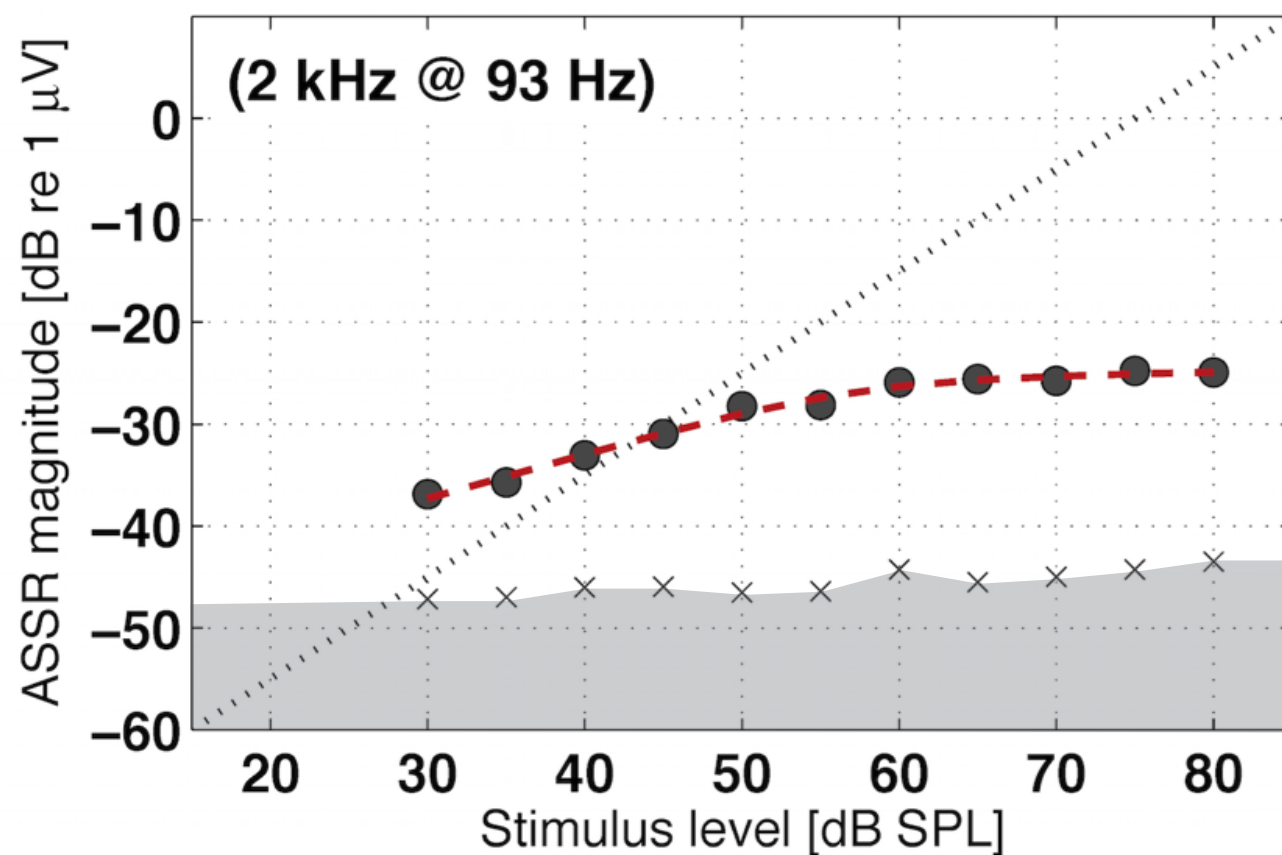


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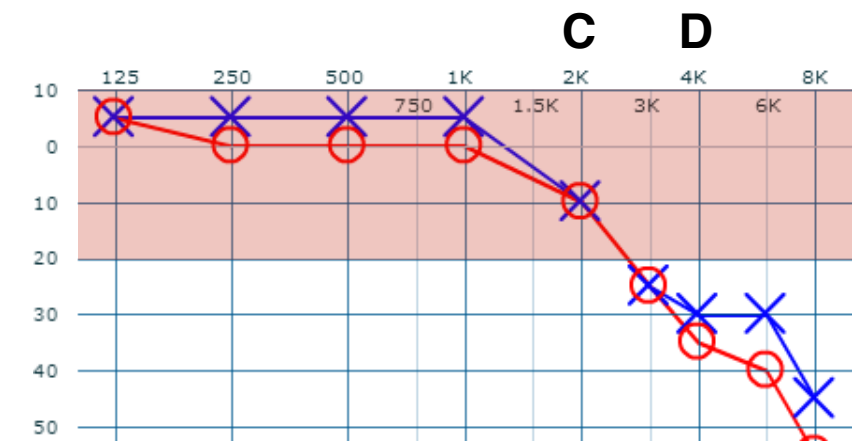
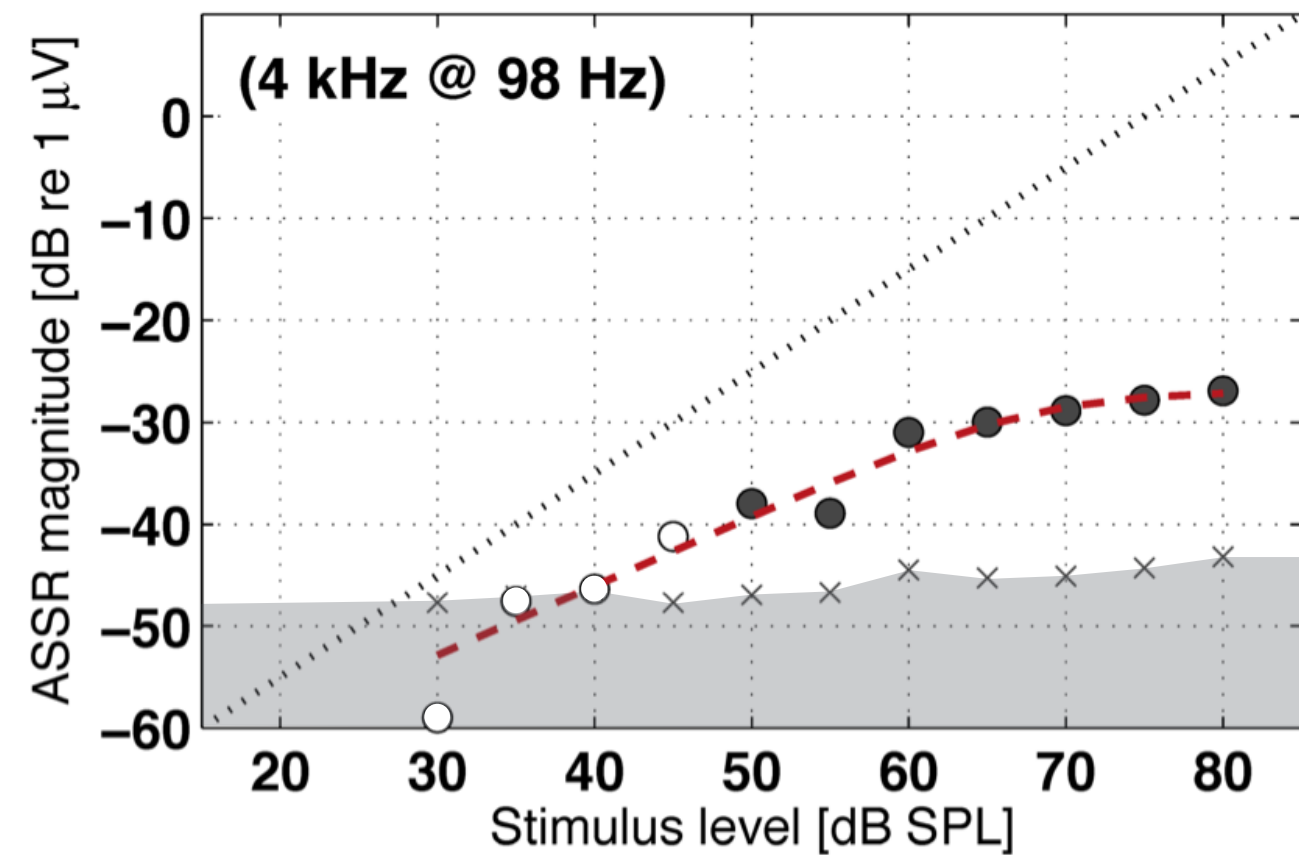


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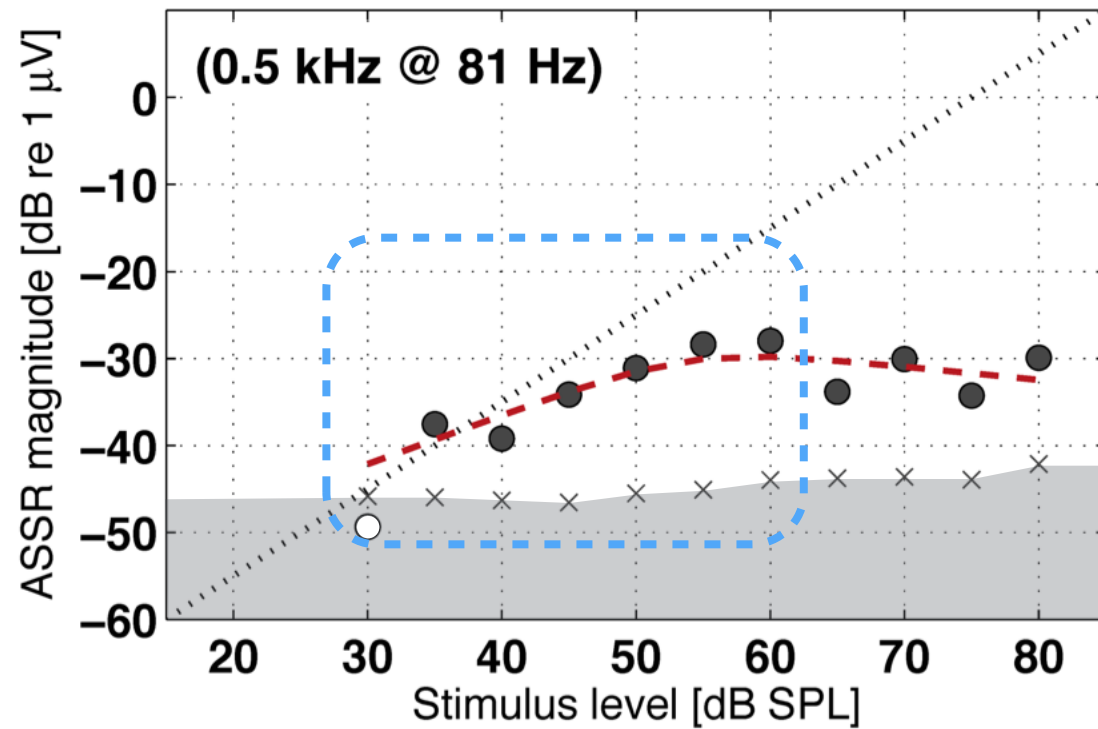


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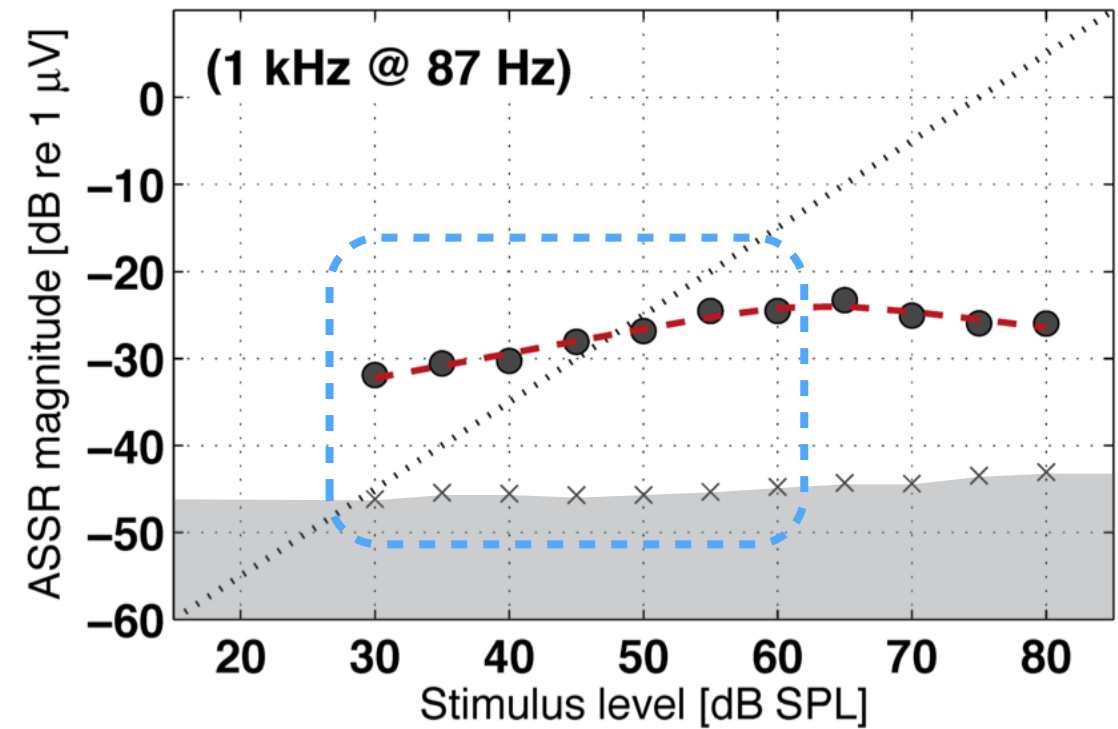


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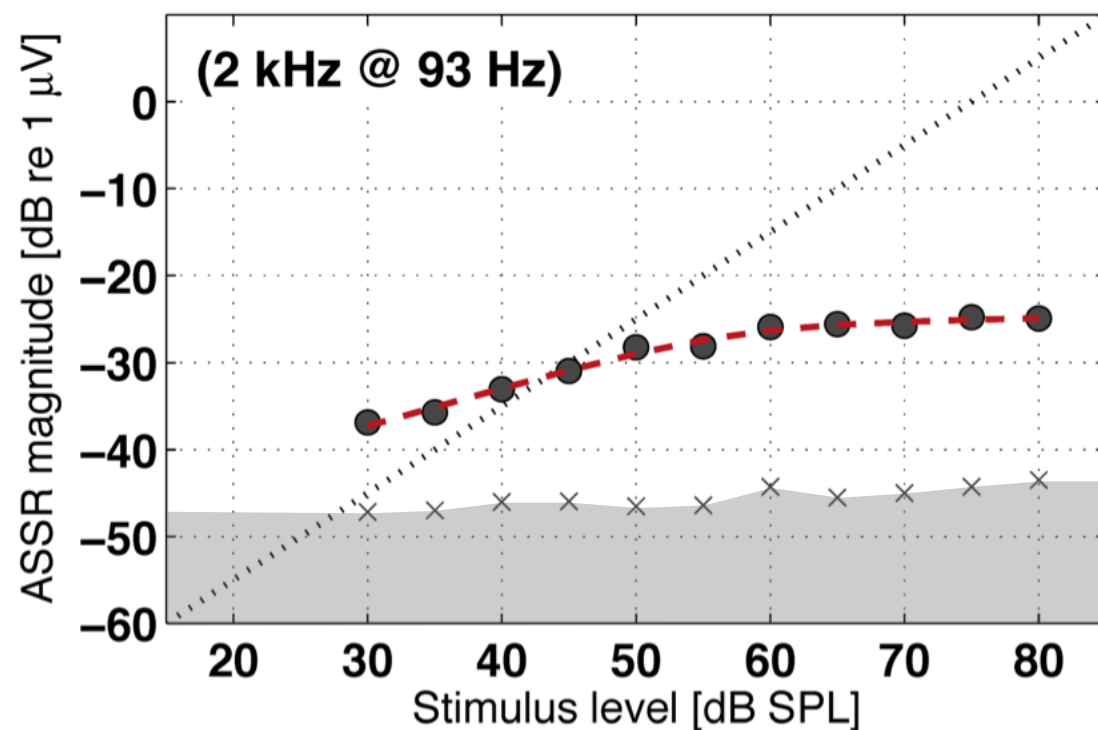
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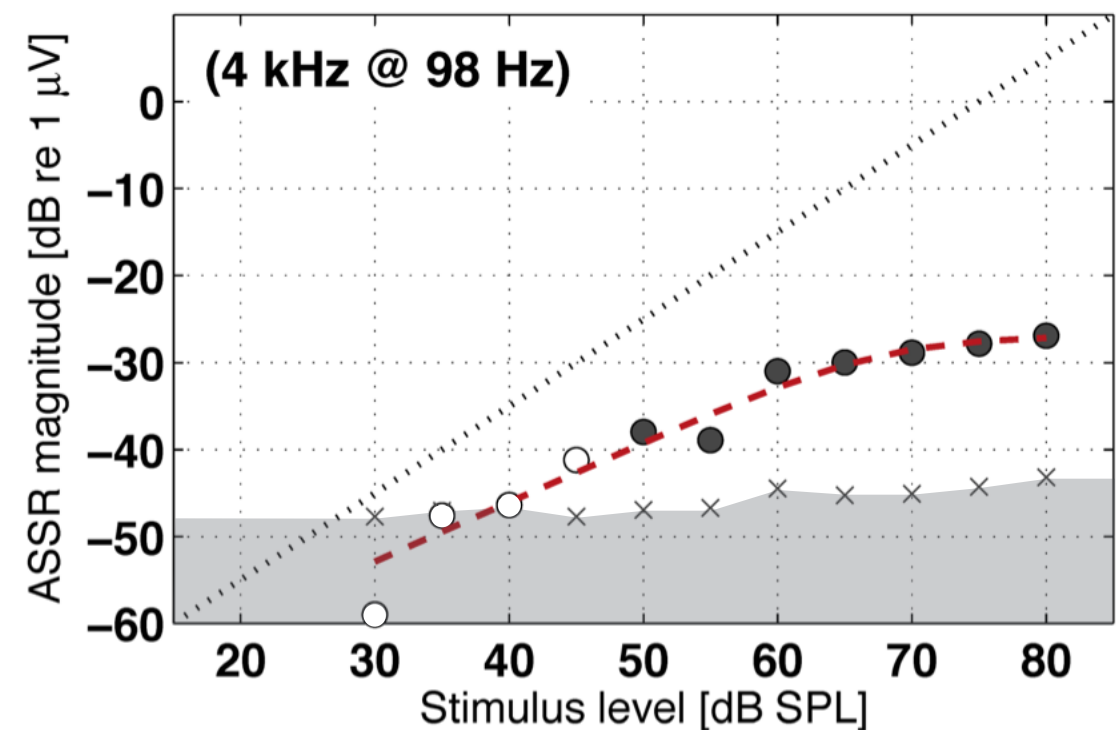
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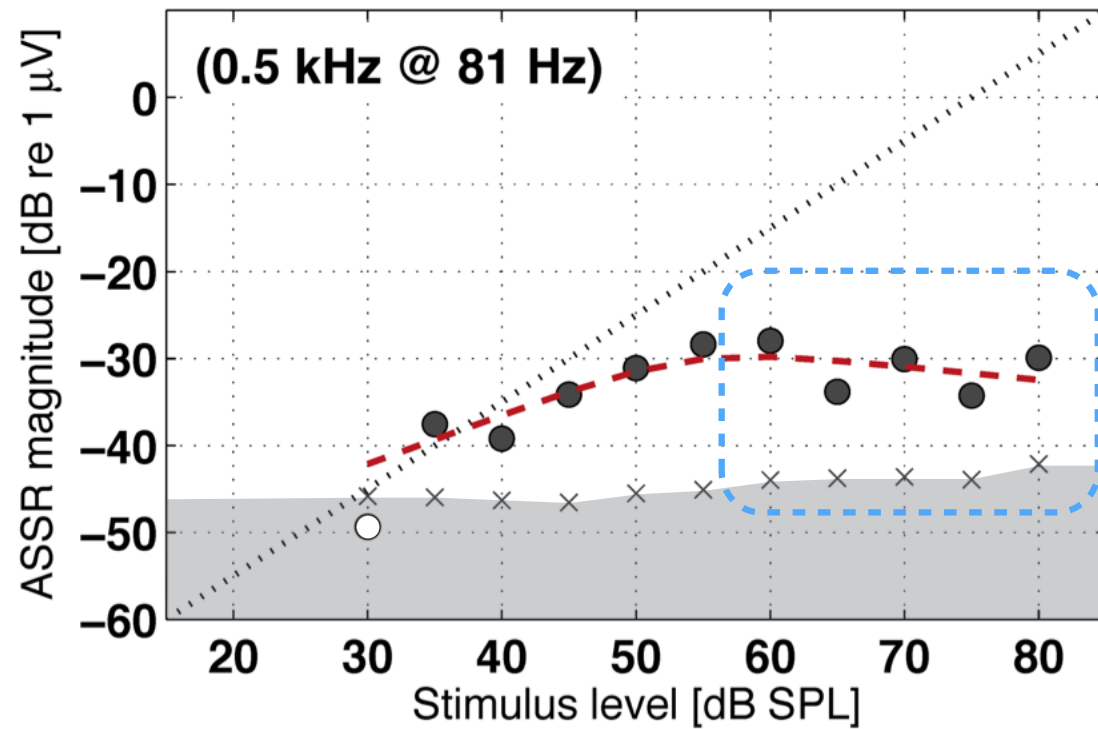


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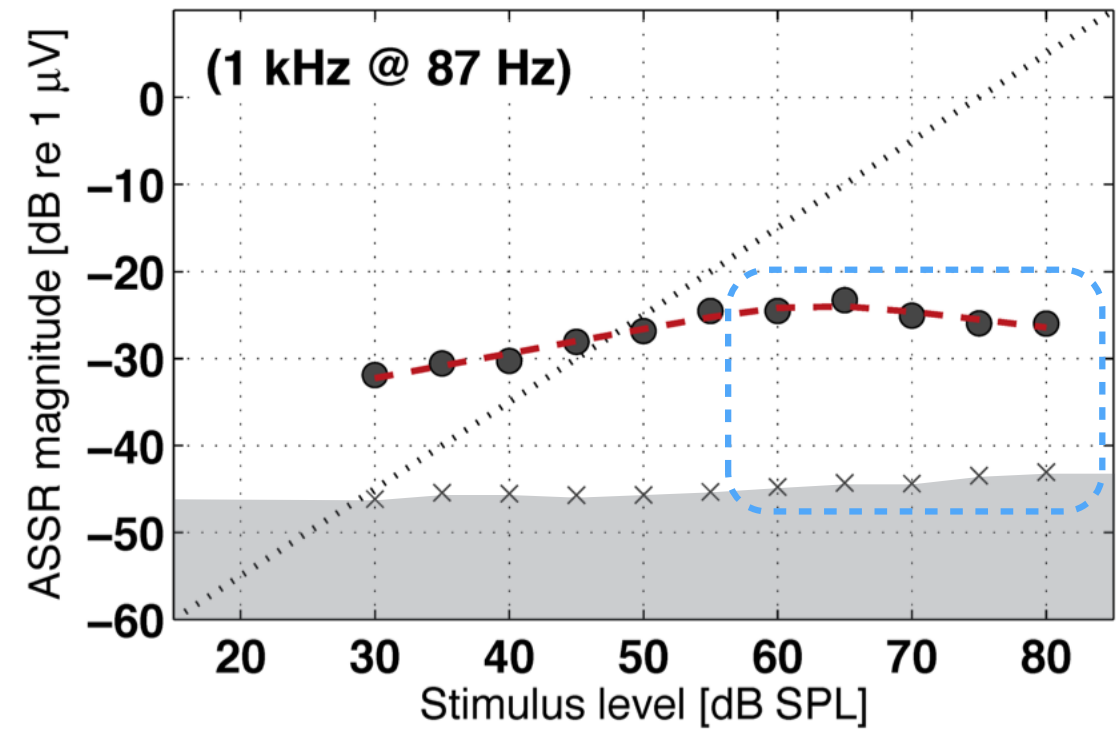


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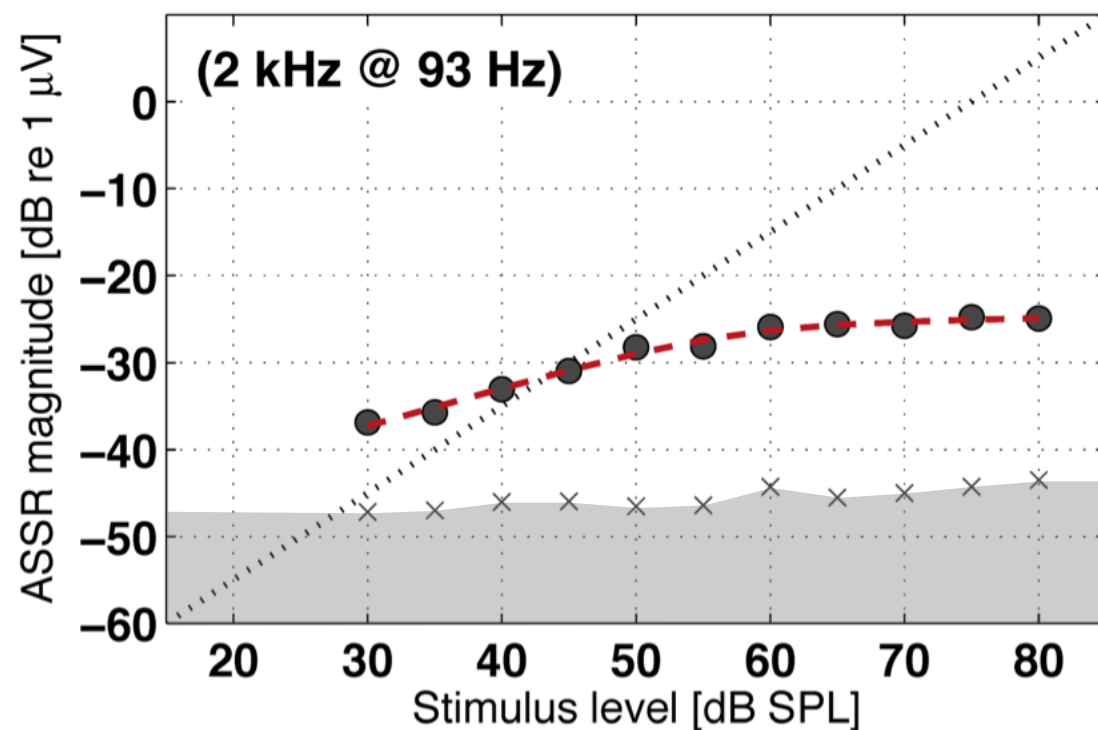
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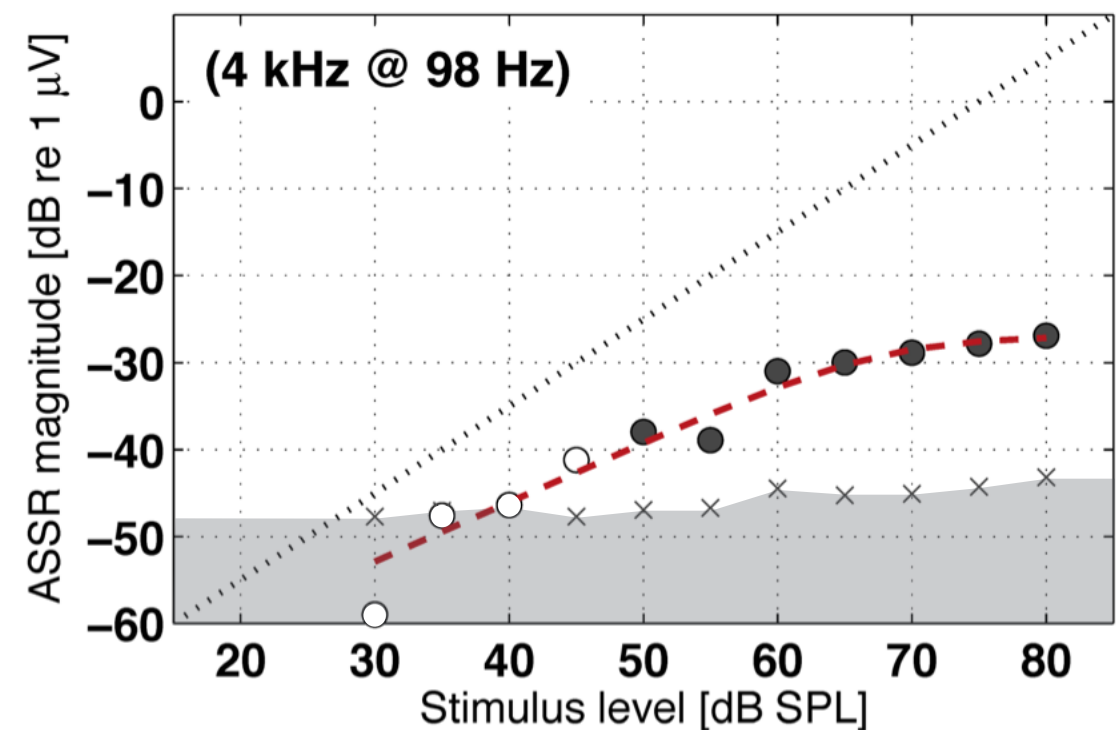
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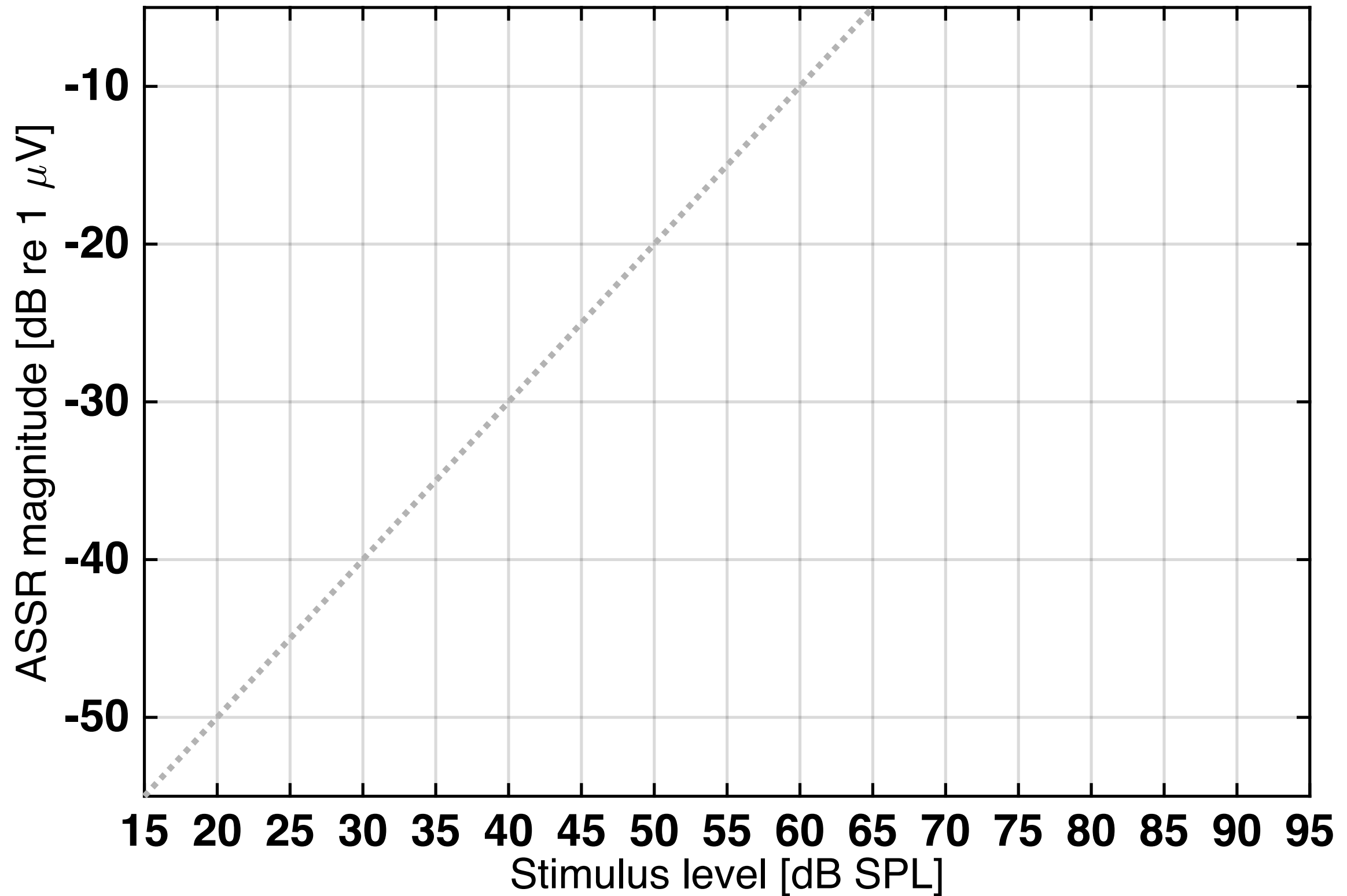


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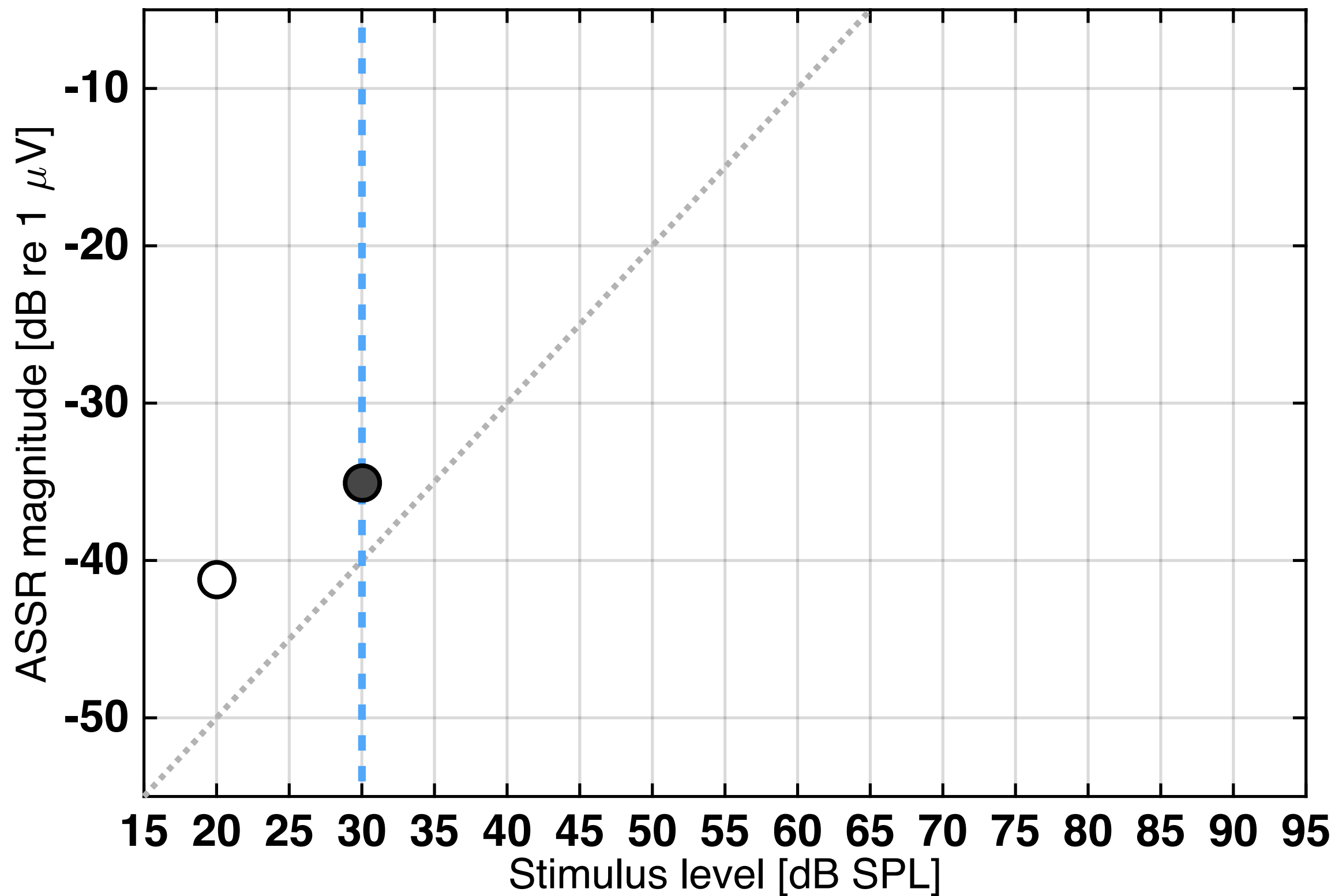


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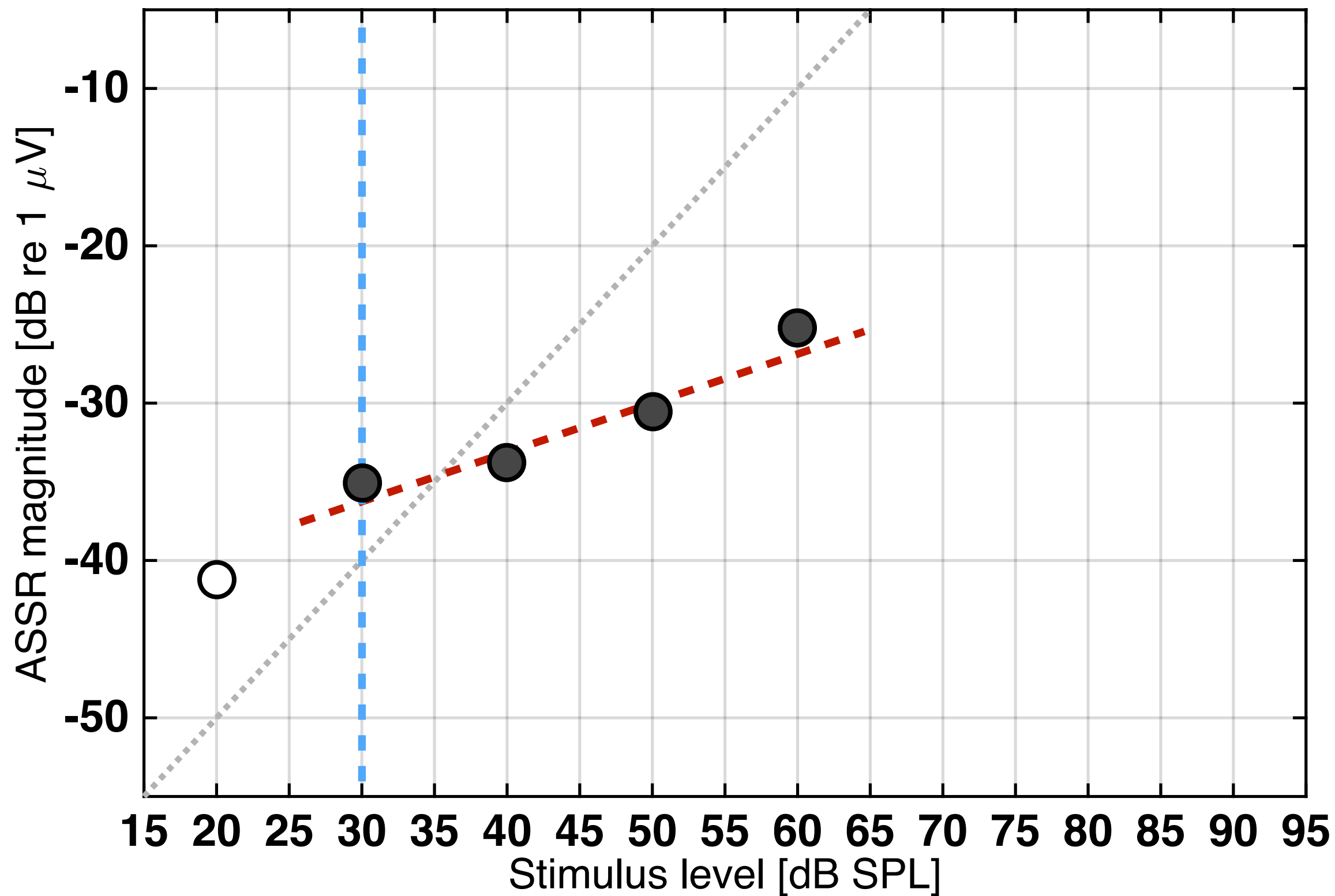
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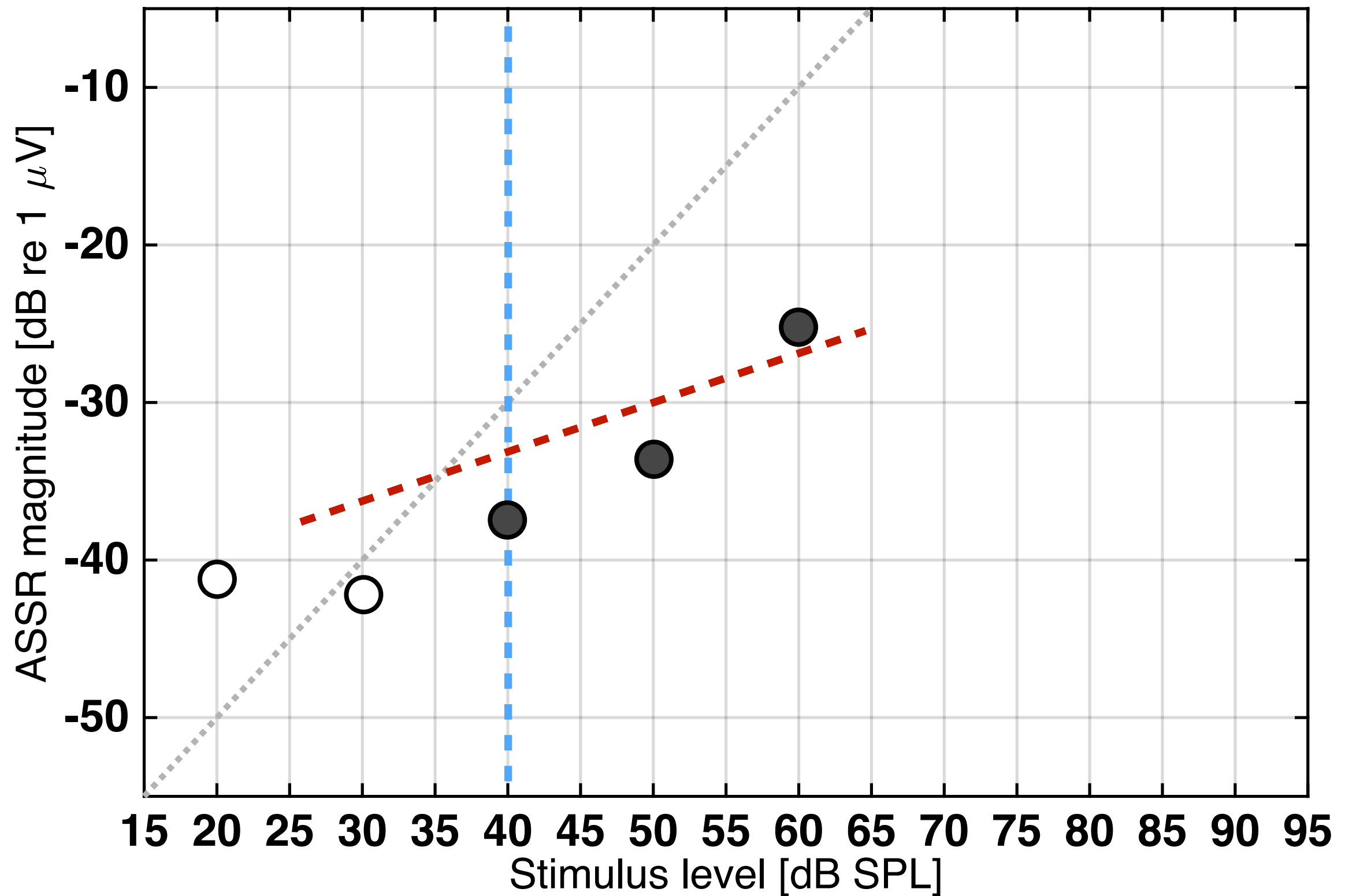
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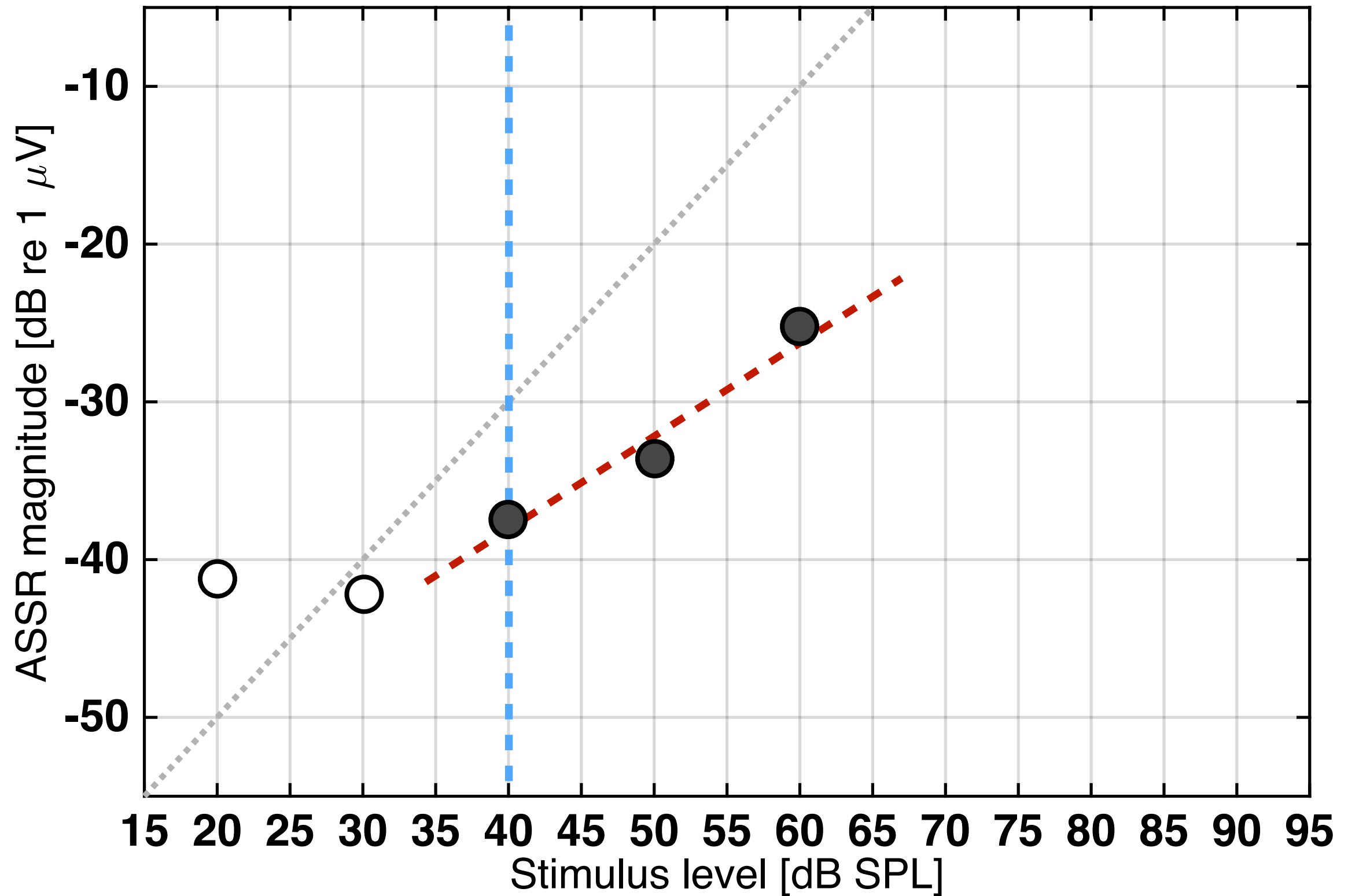
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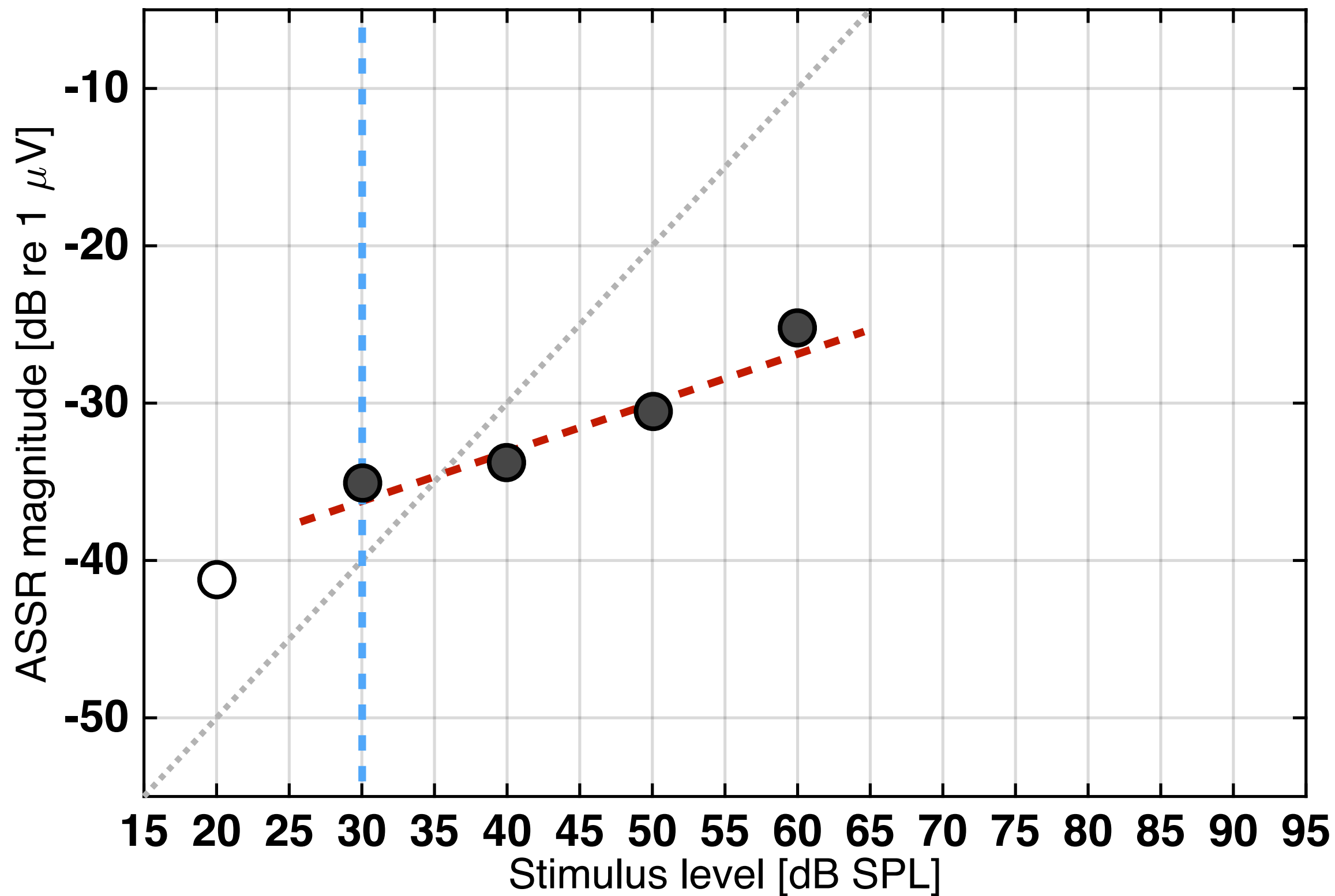
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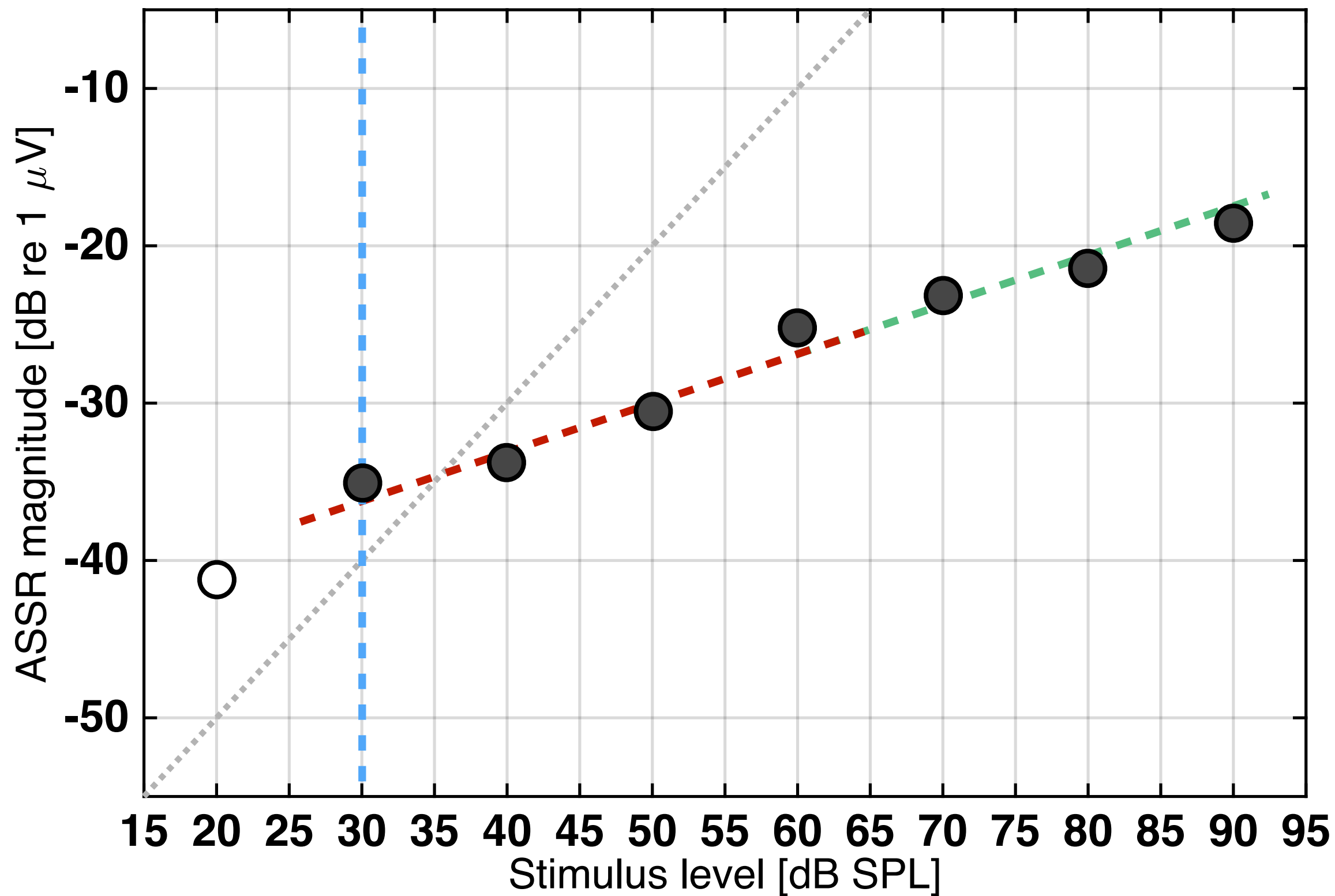
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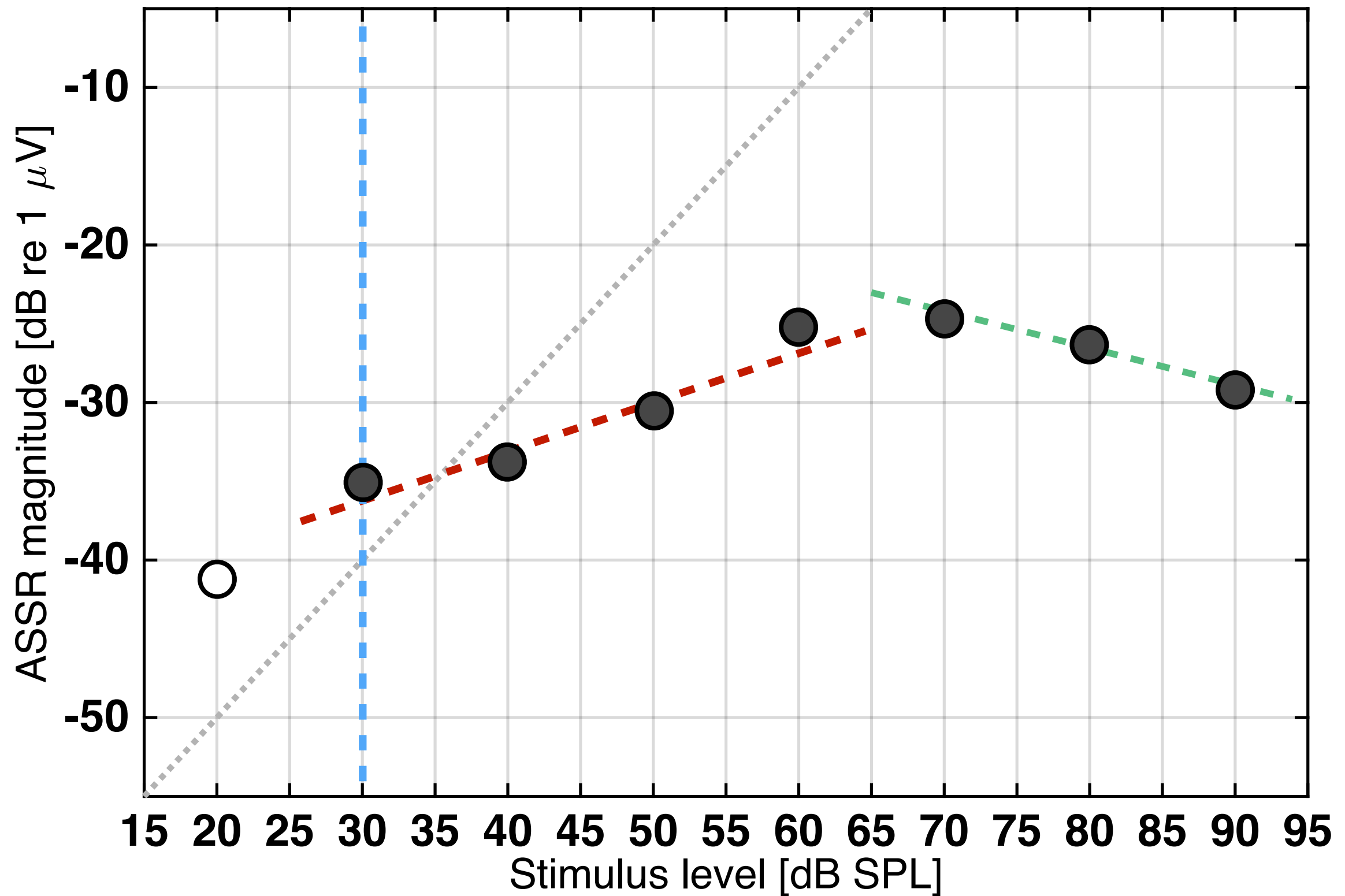
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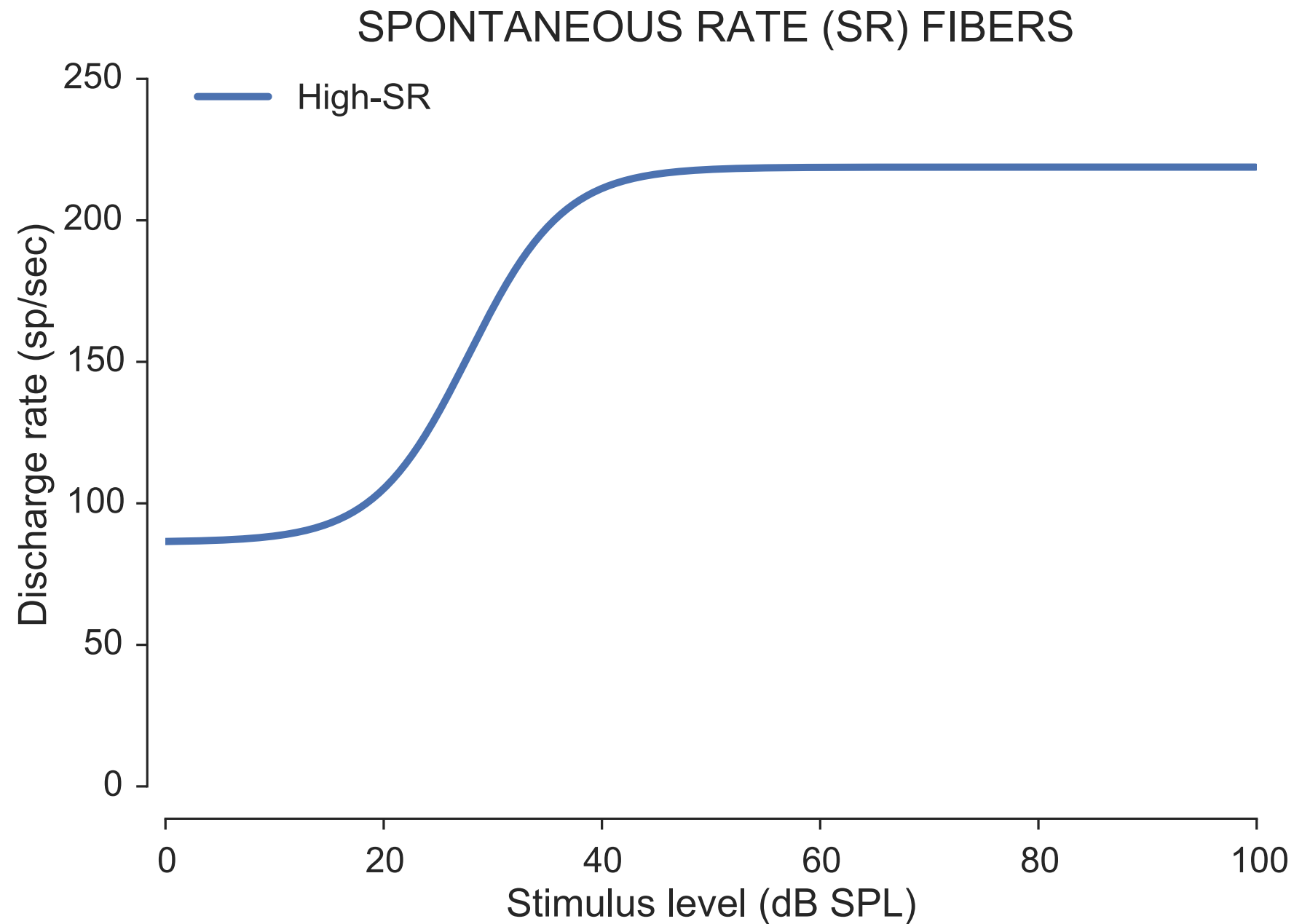
Intermediate summary



Contribution of SR fibers to deafferentation

Lieberman (1978)

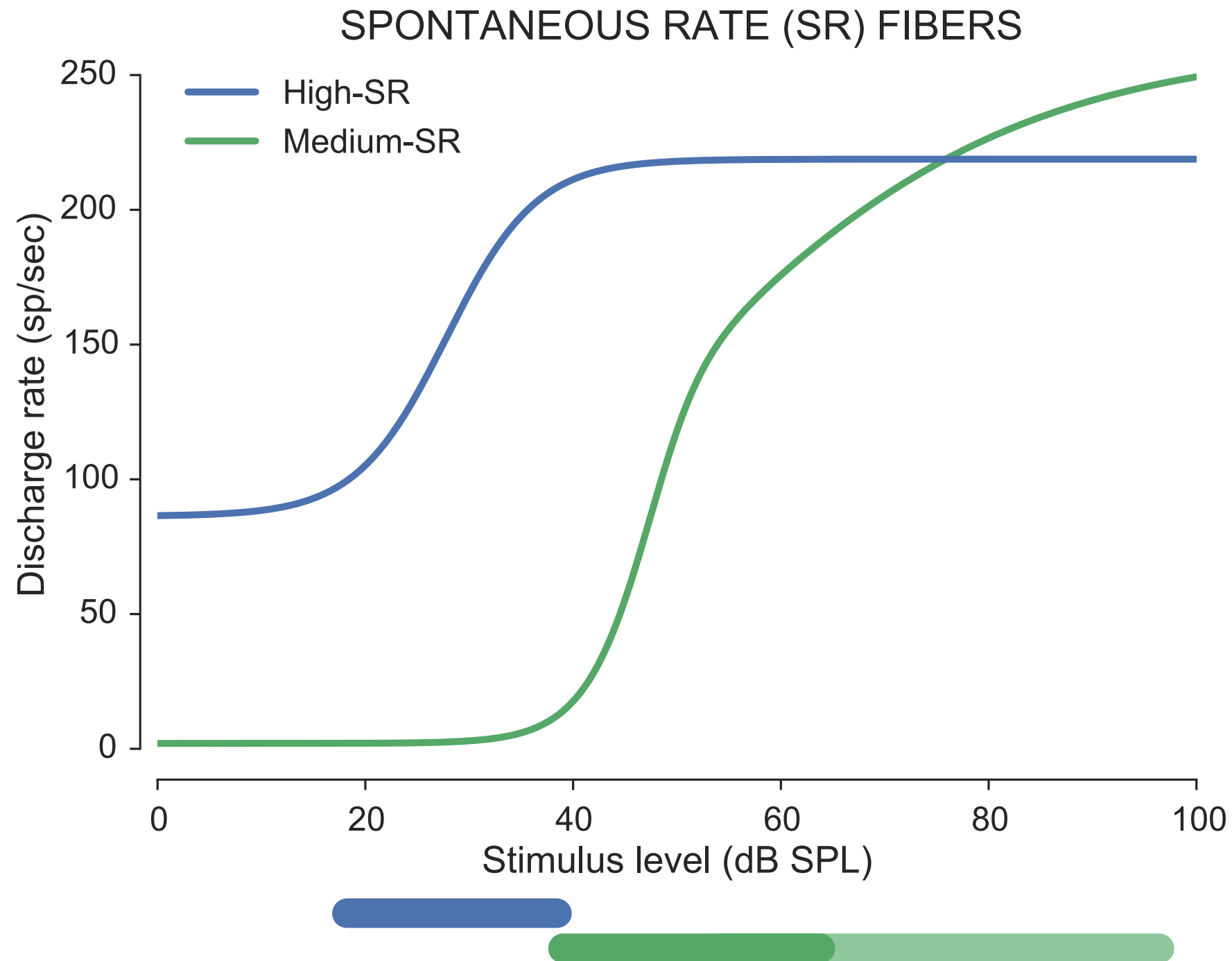
Yates (1990)



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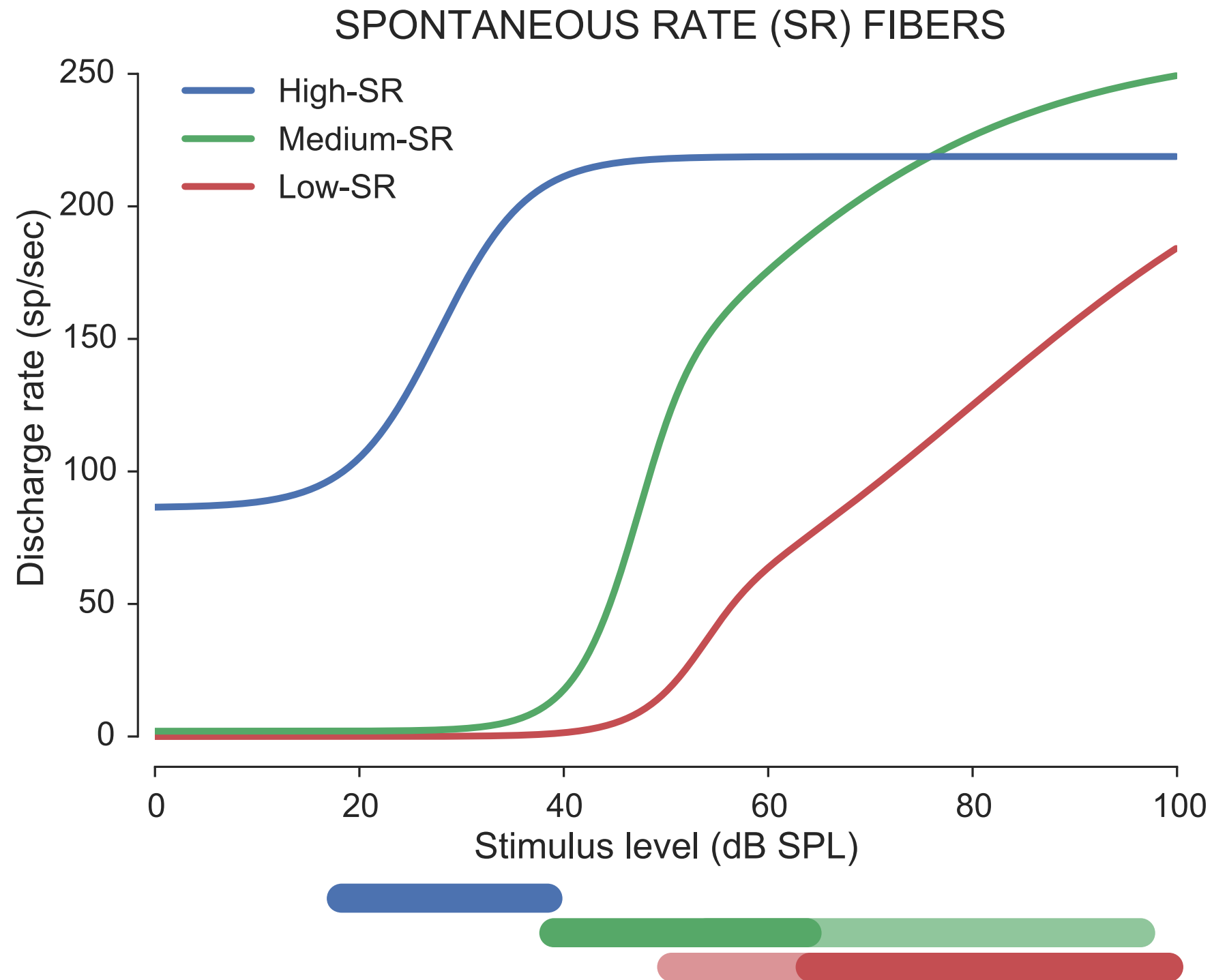
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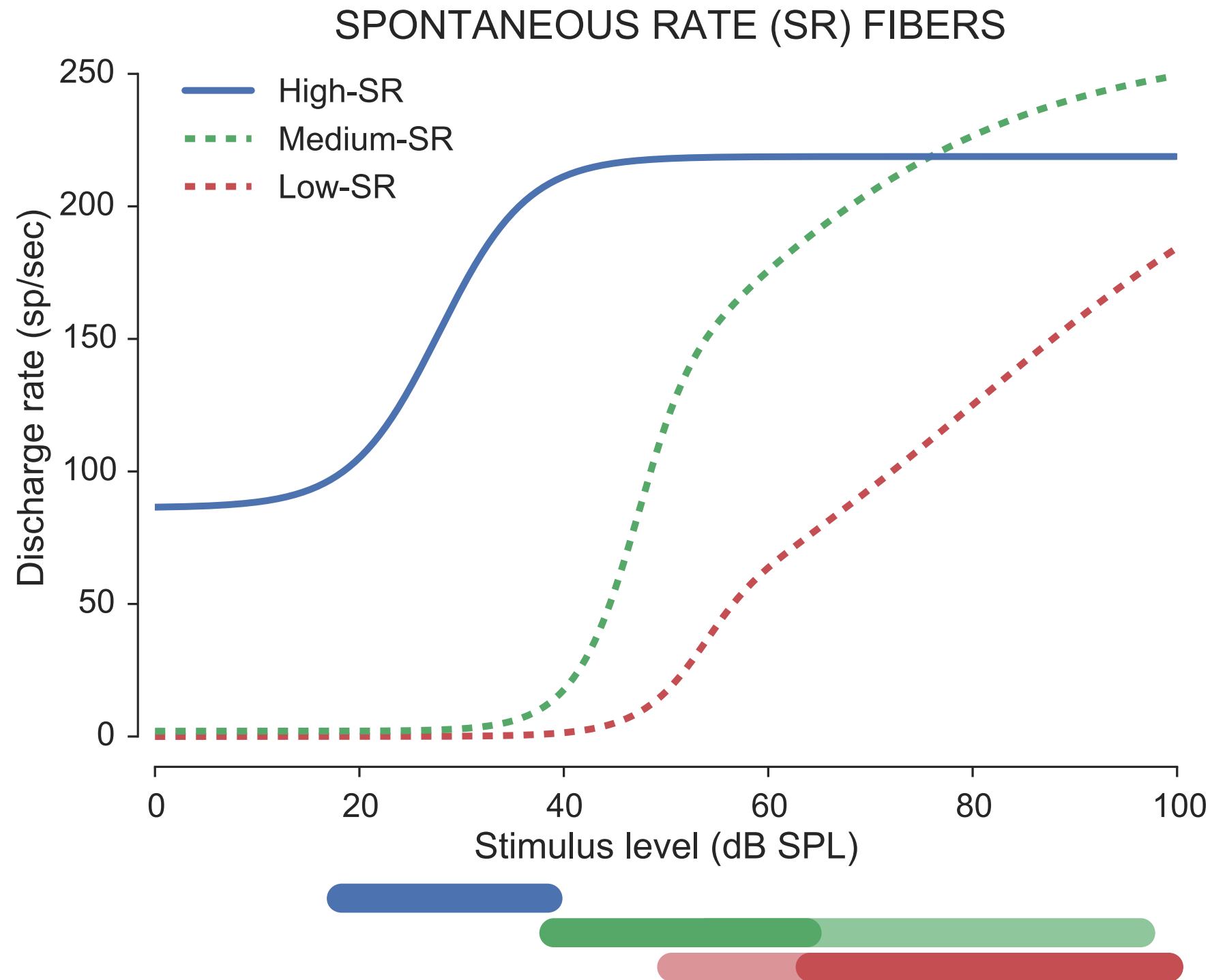
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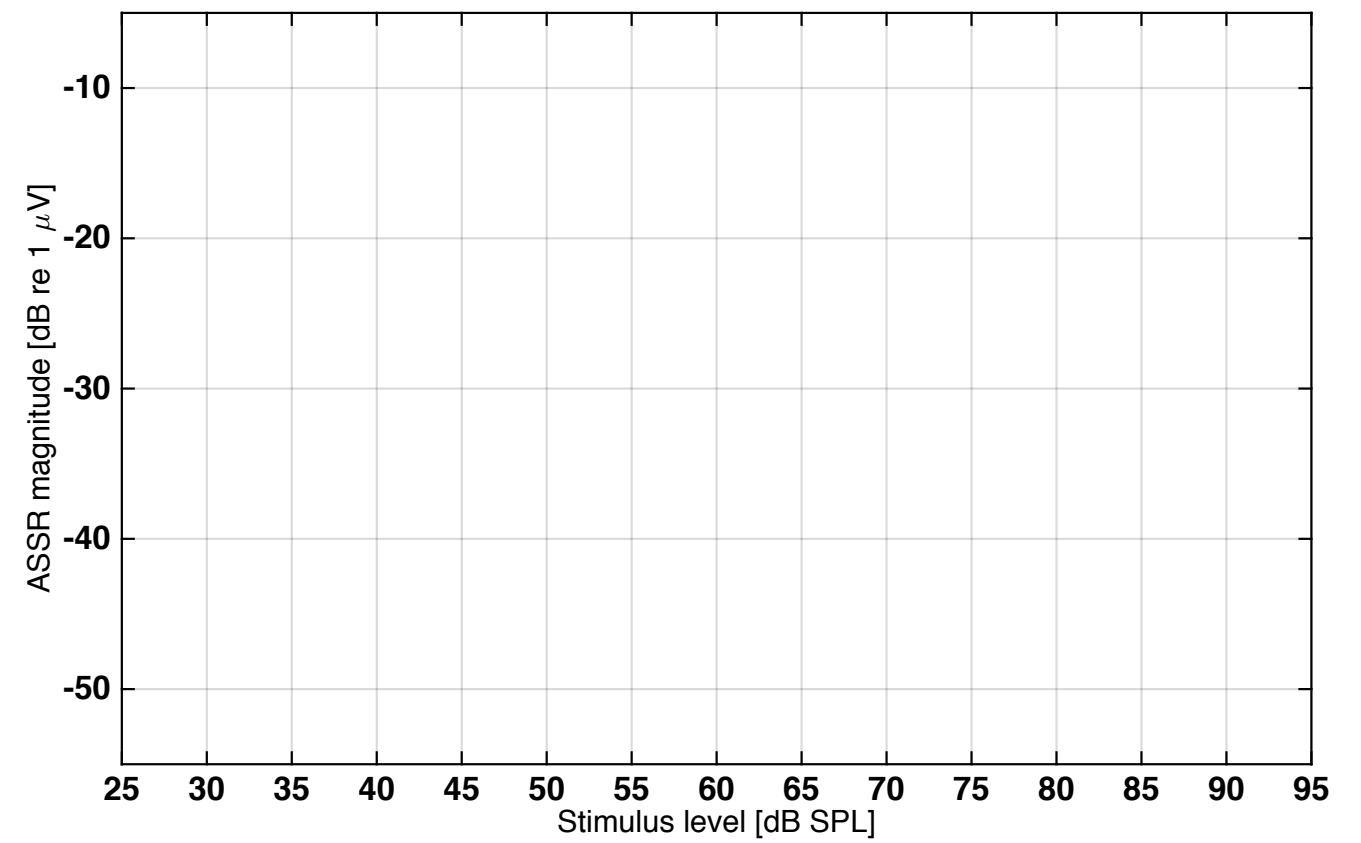
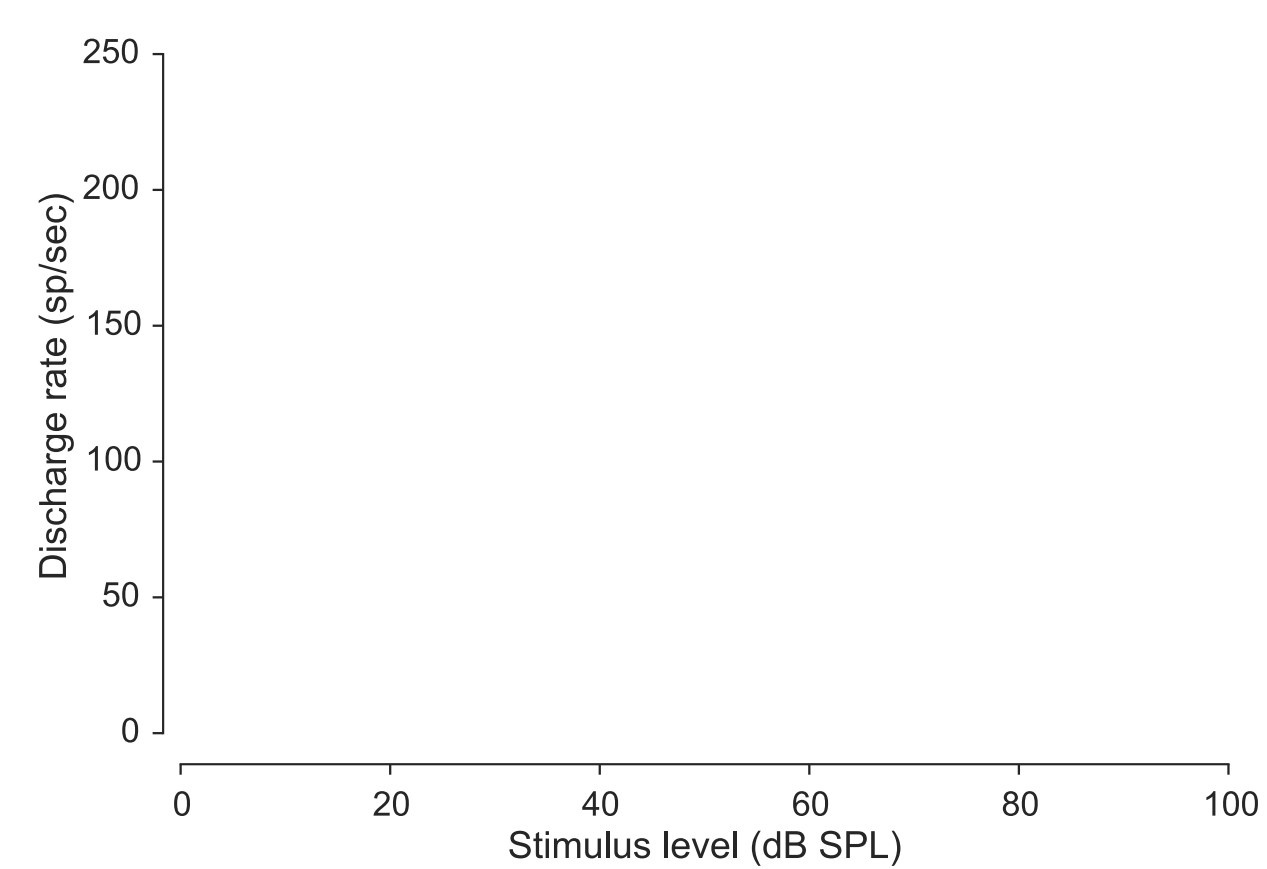
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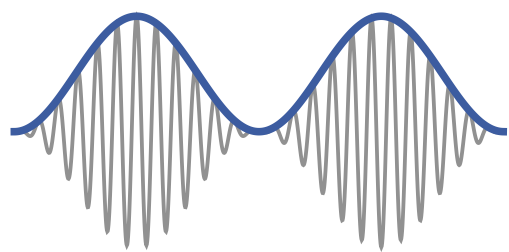
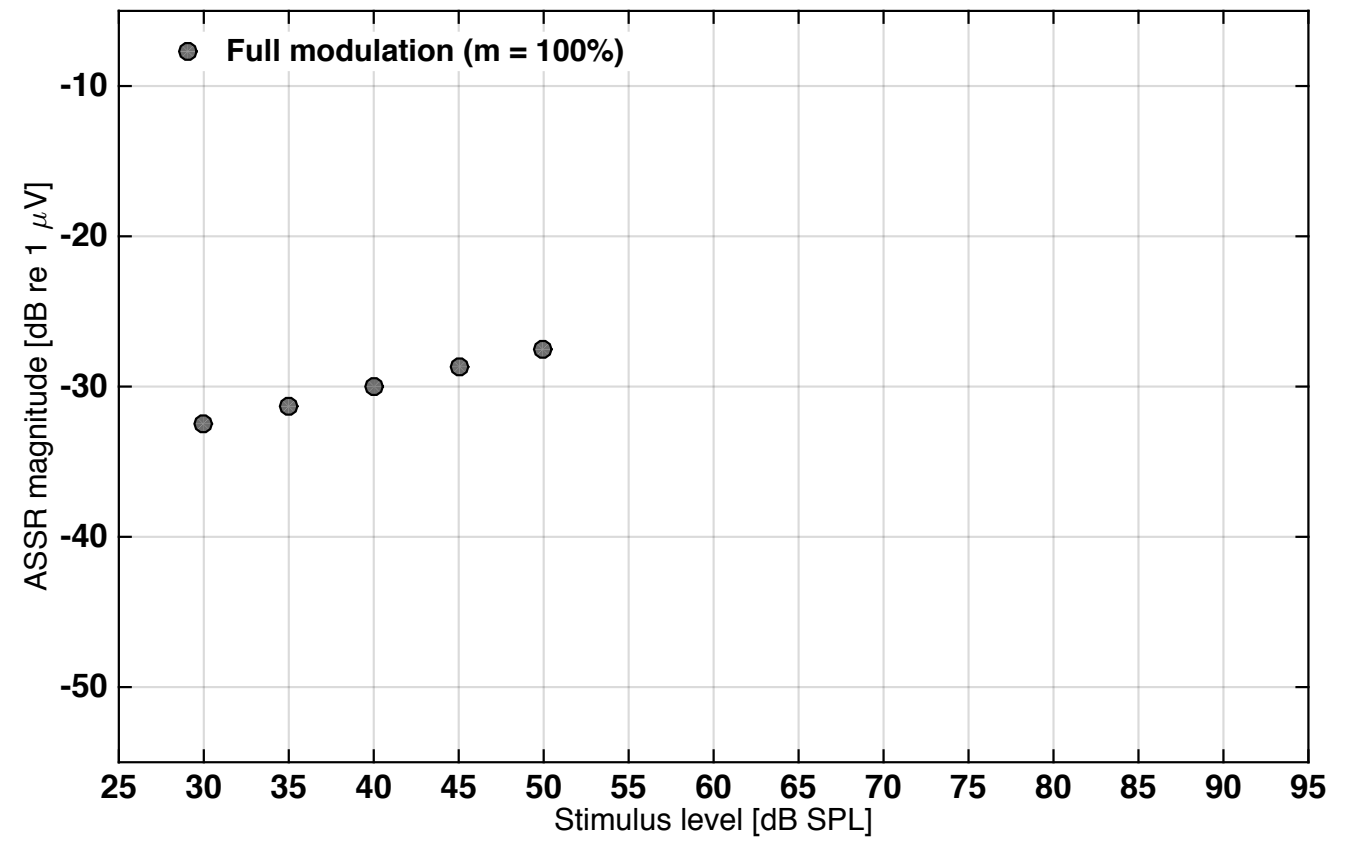
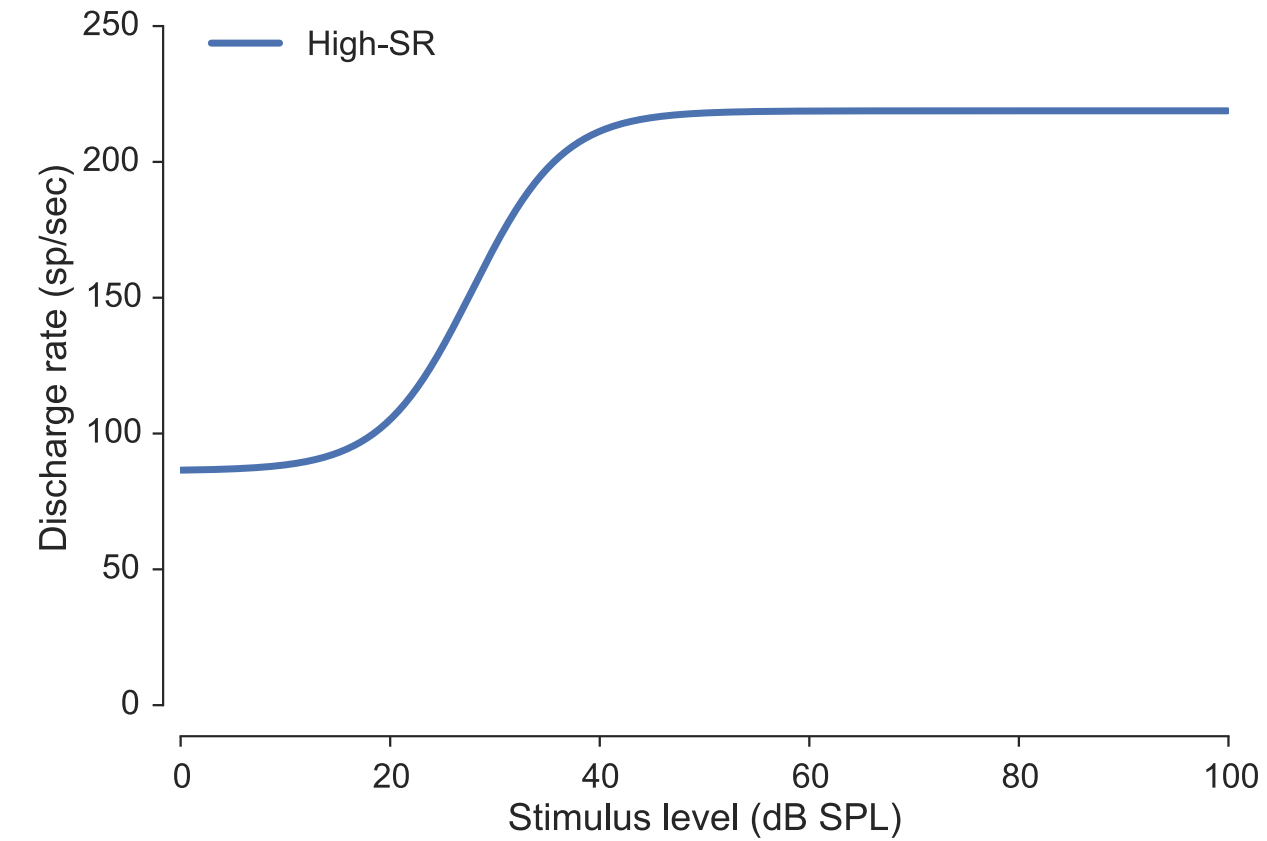
- Furman *et al.* (2013) showed that ANF “**deafferentation**” due to noise over-exposure is more **selective** to **medium-** and **low-SR fibers**

Potential explanation

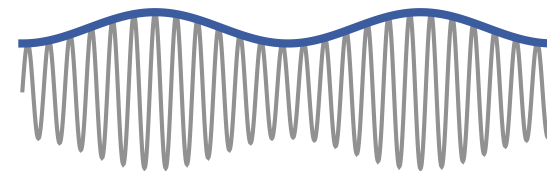
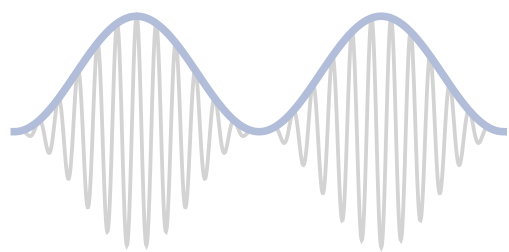
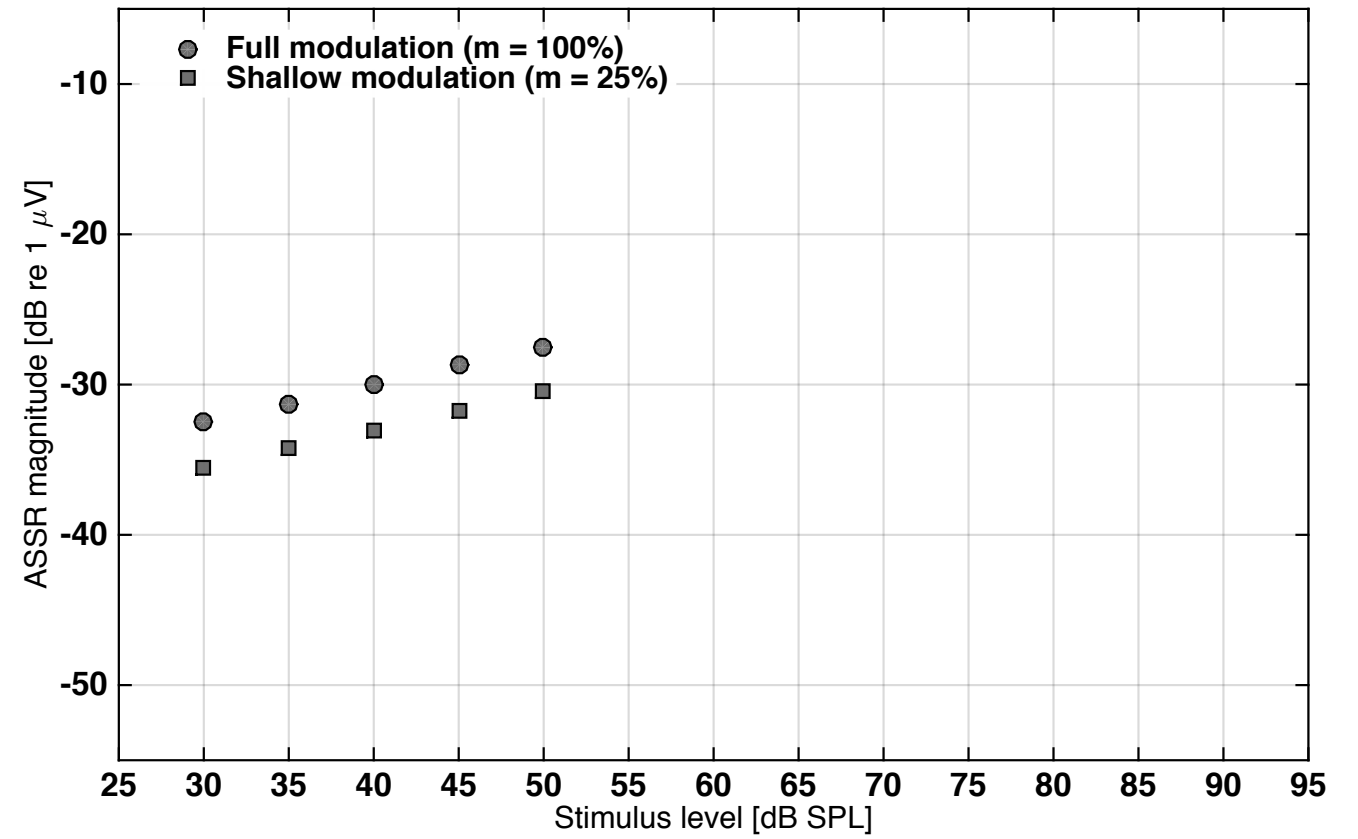
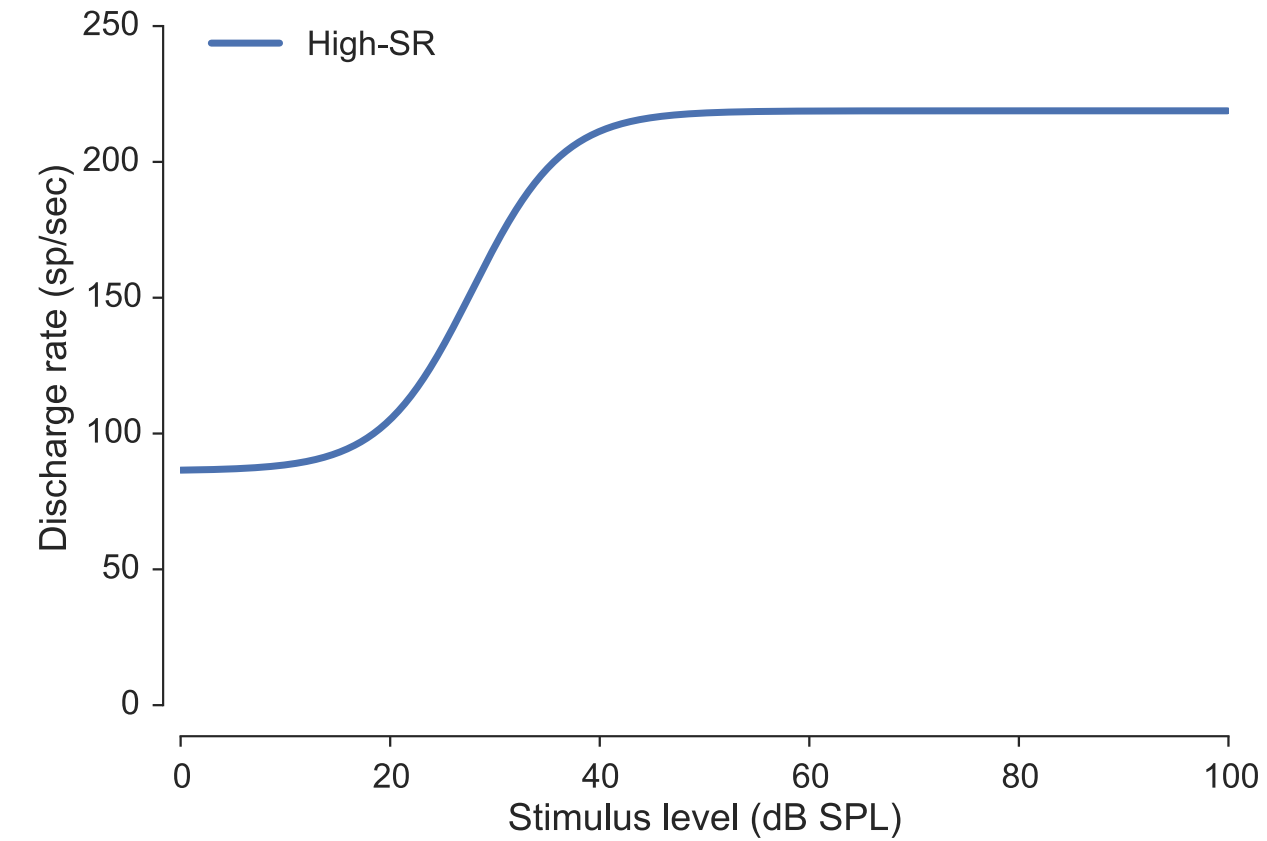
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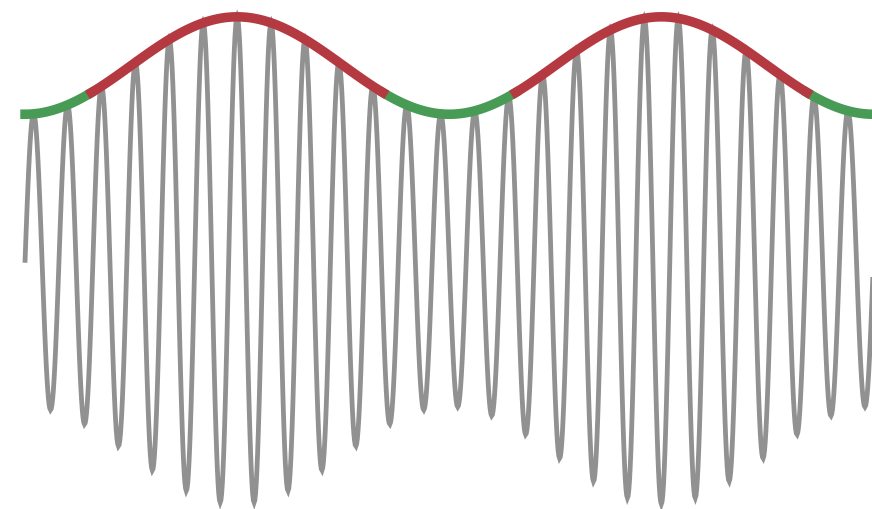
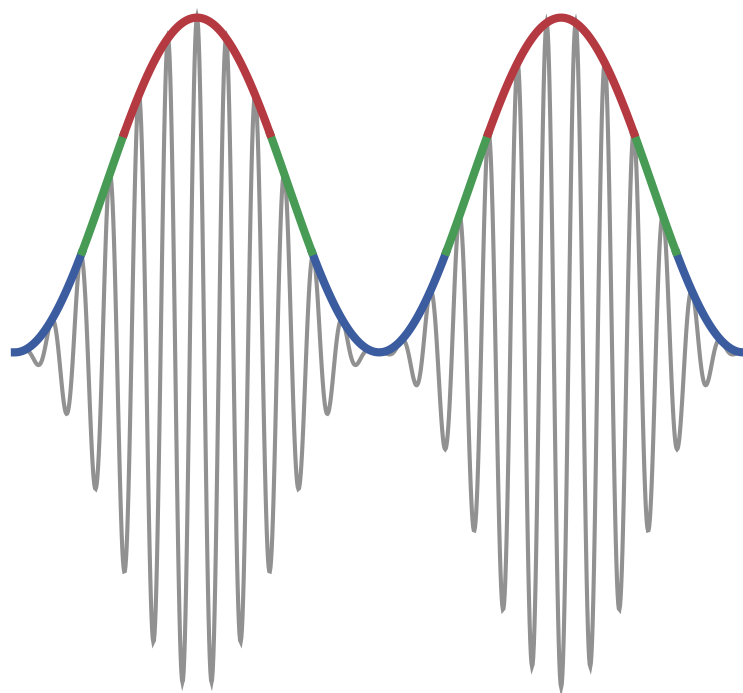
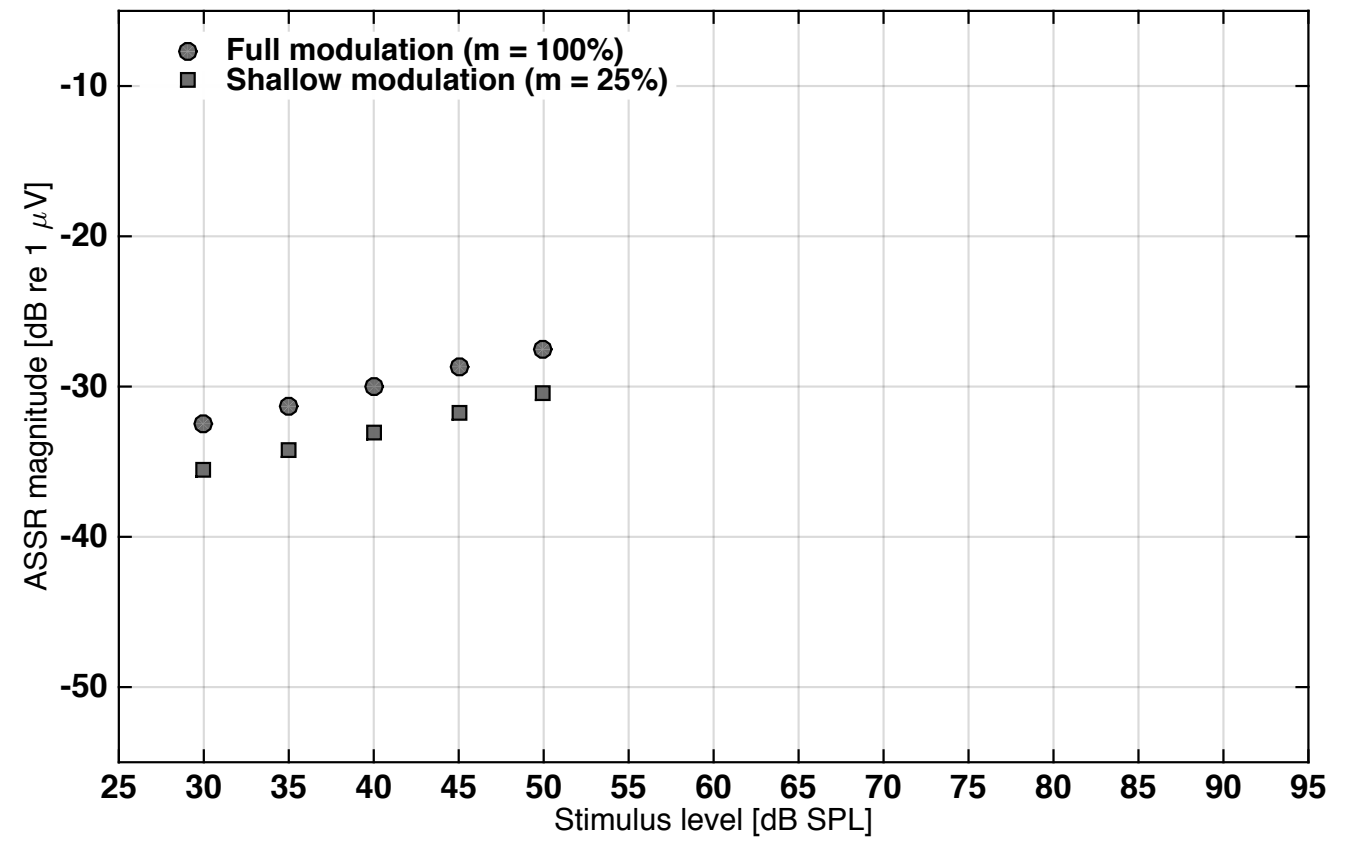
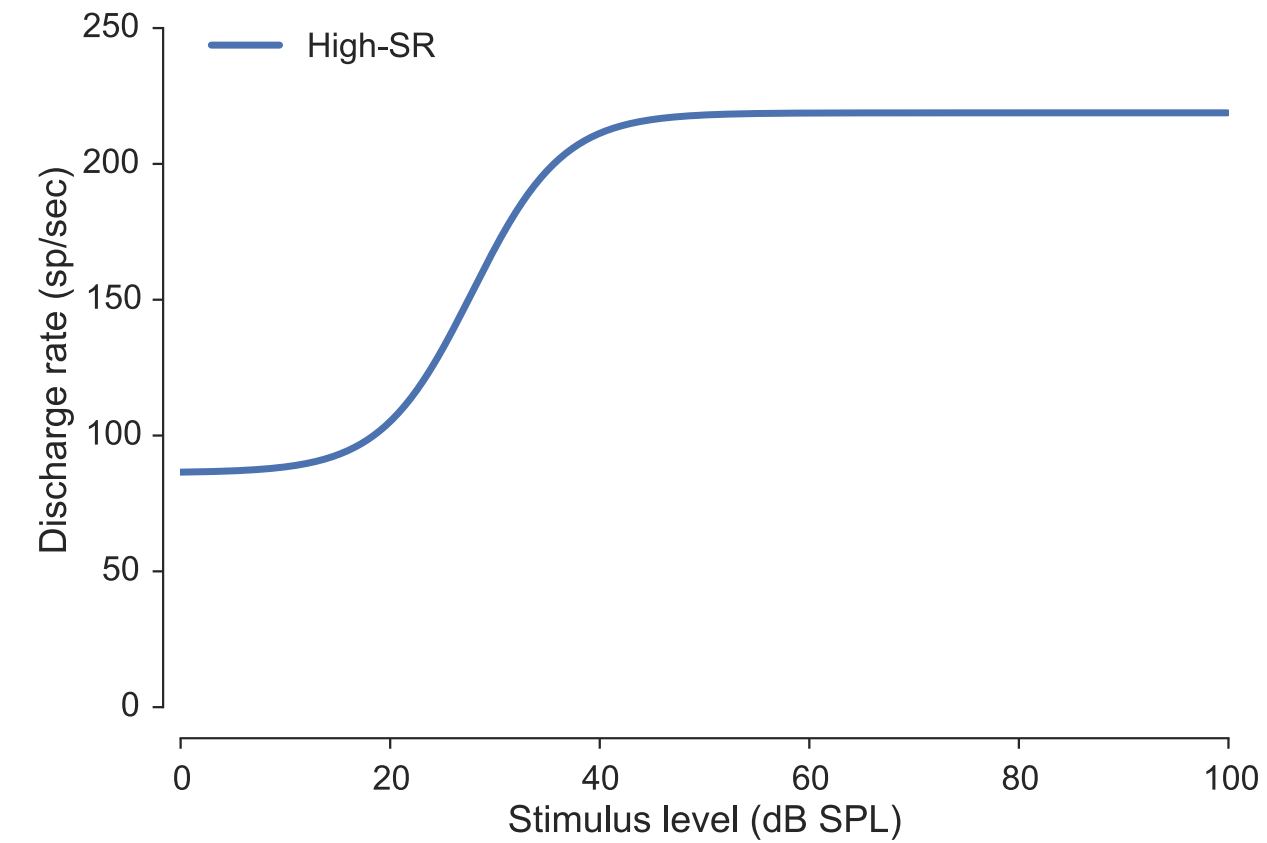
Potential explanation



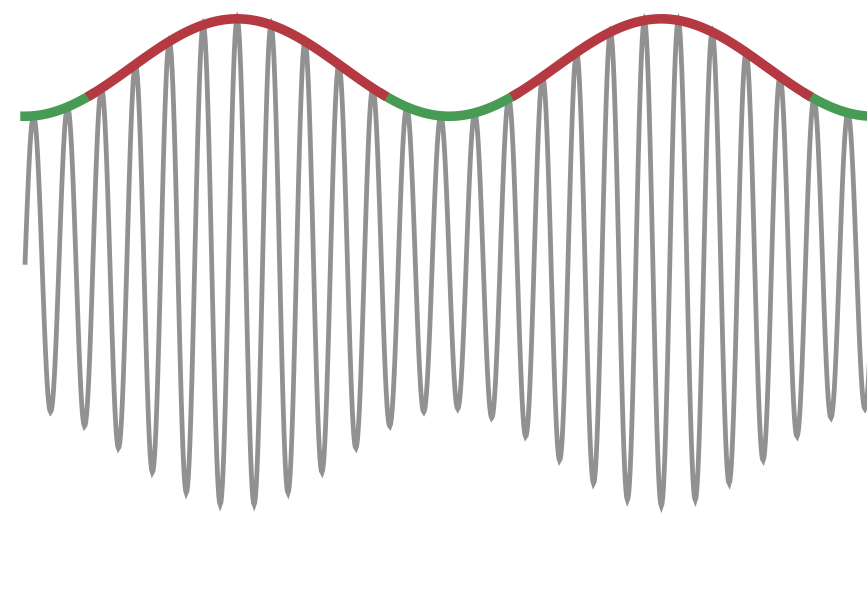
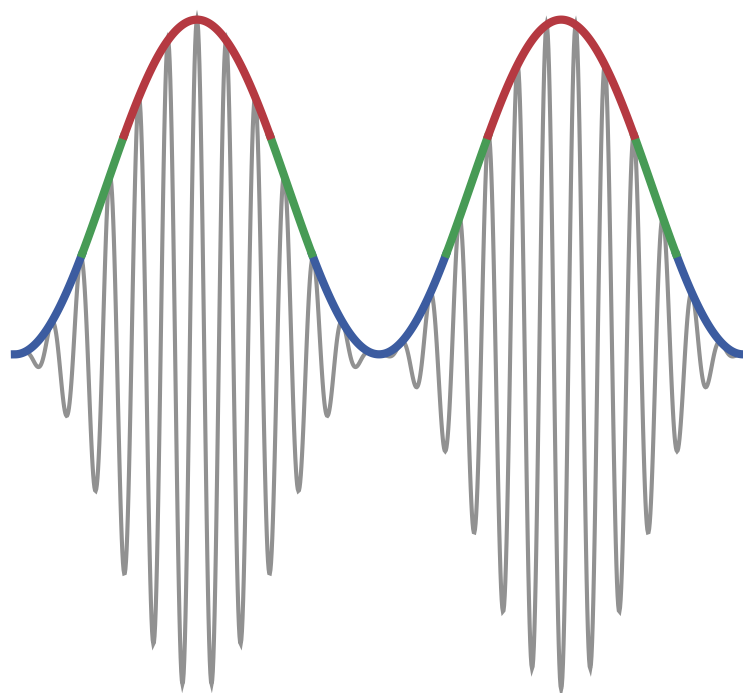
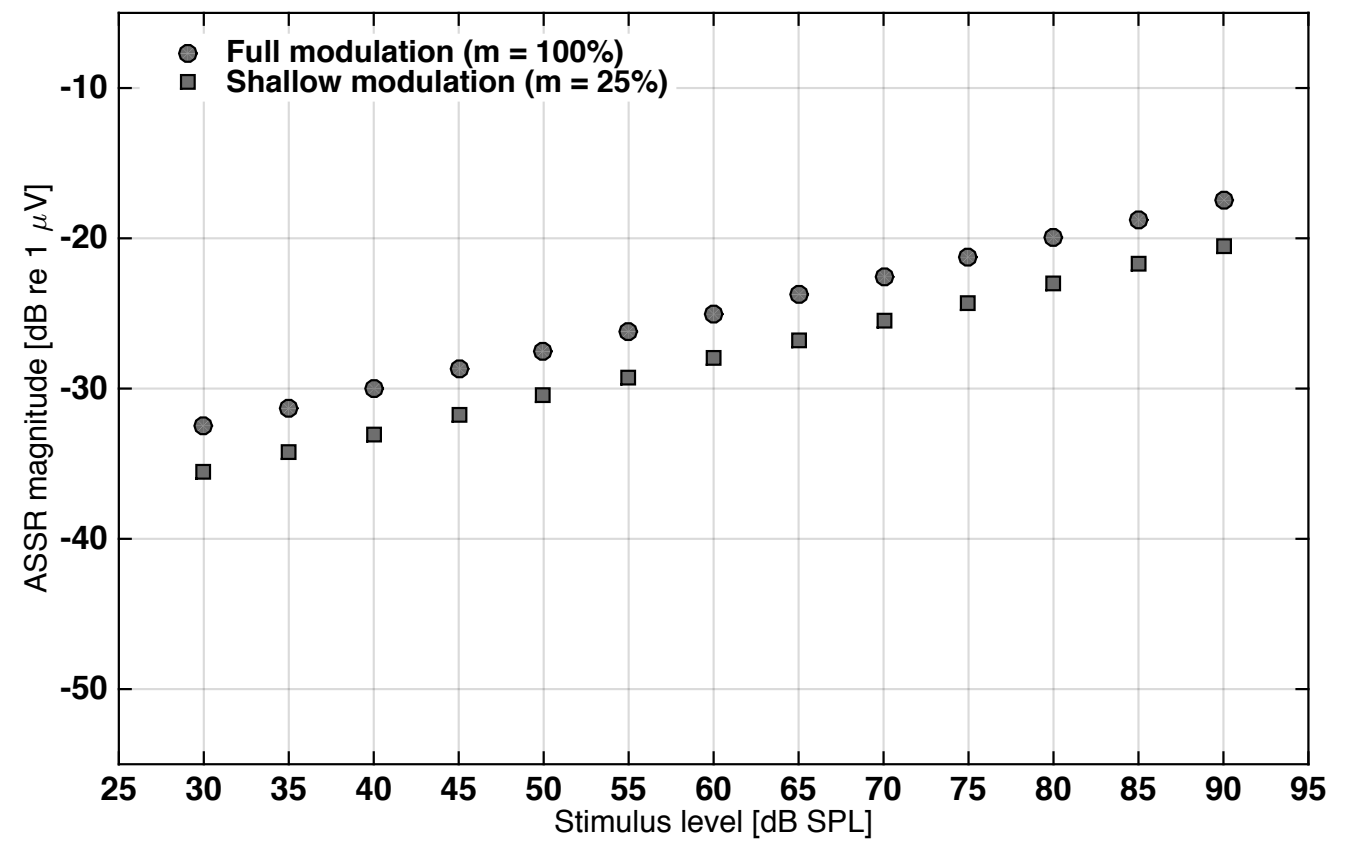
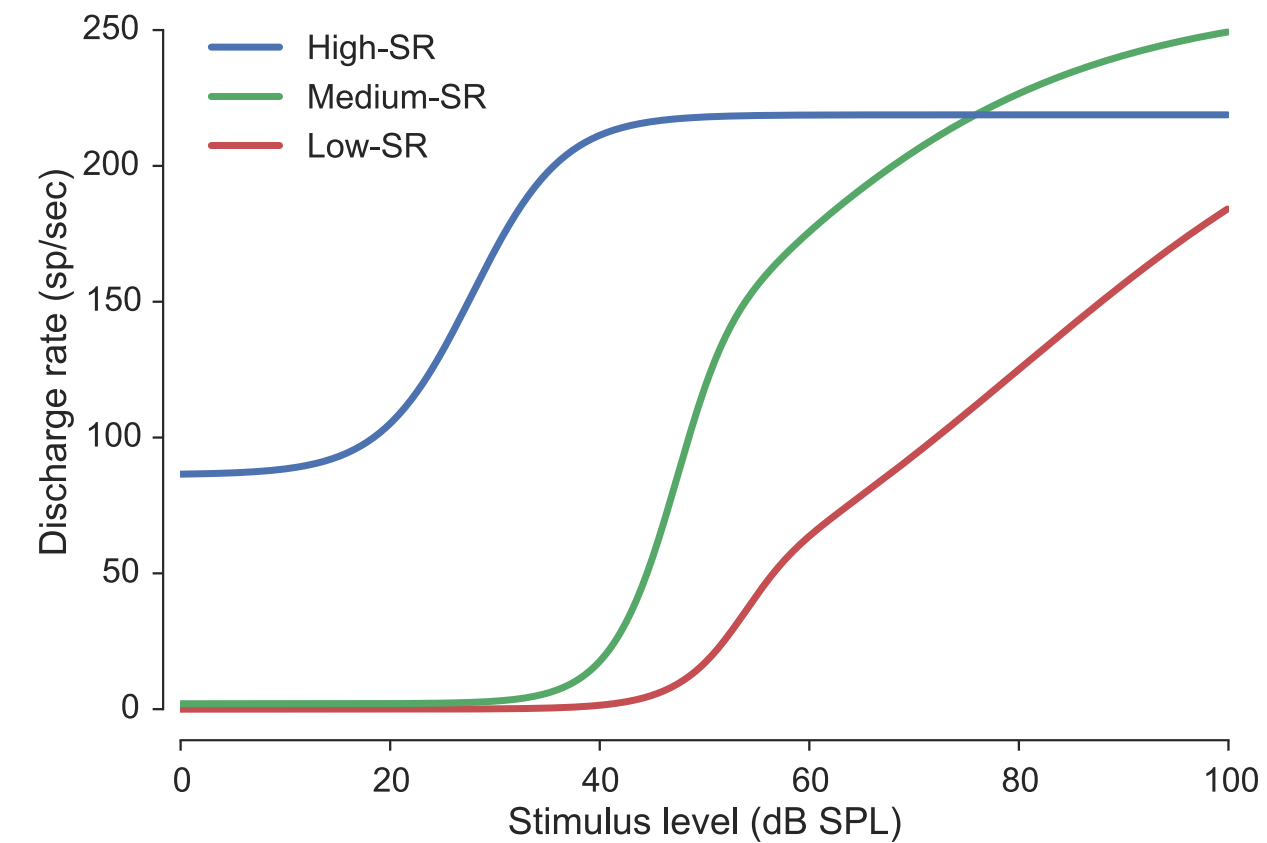
Potential explanation



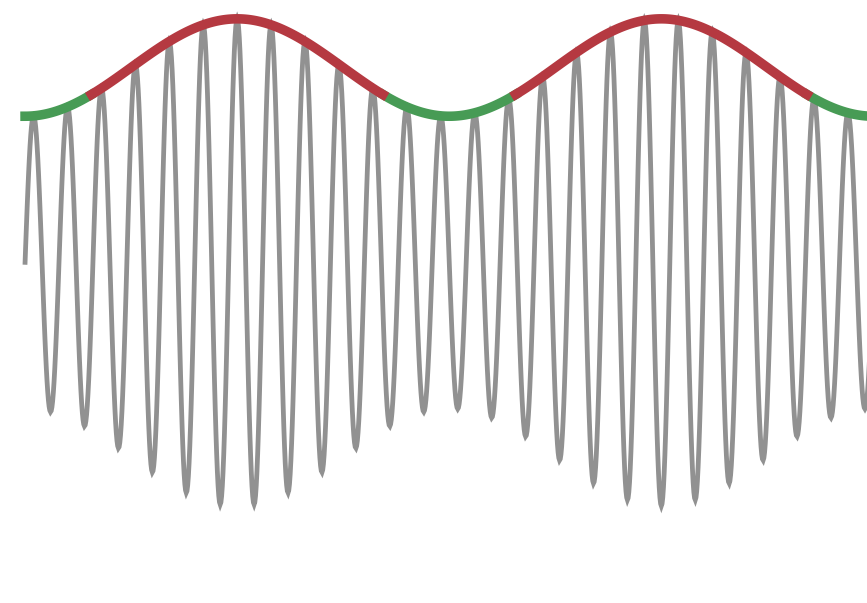
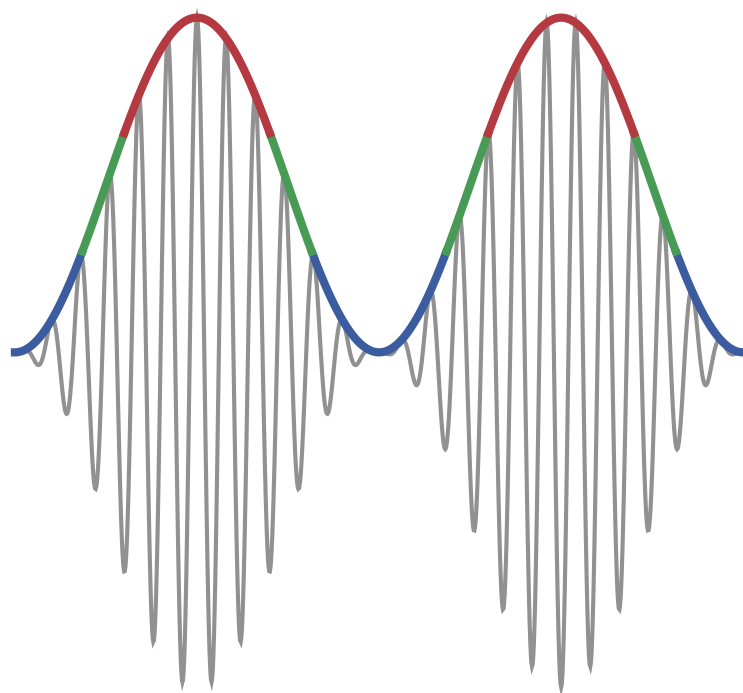
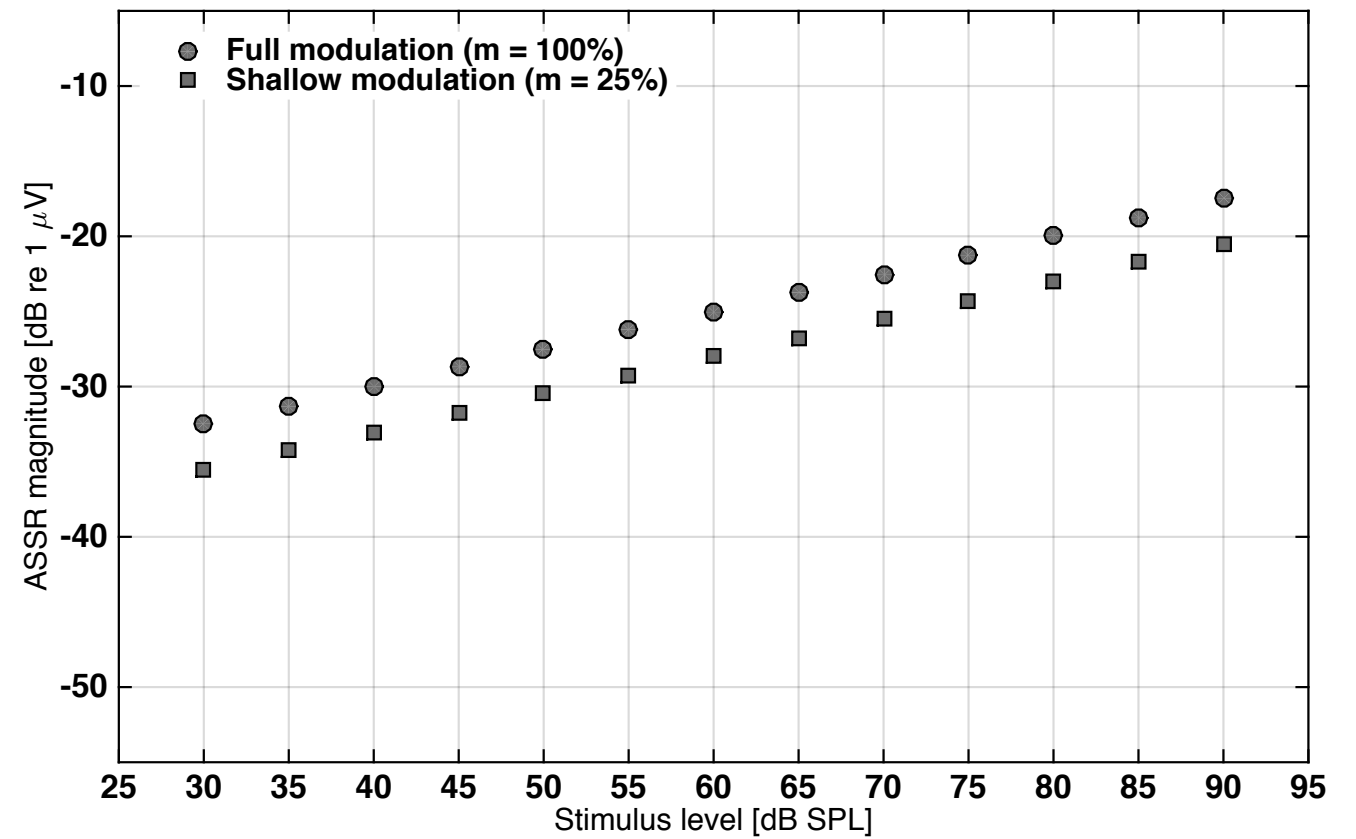
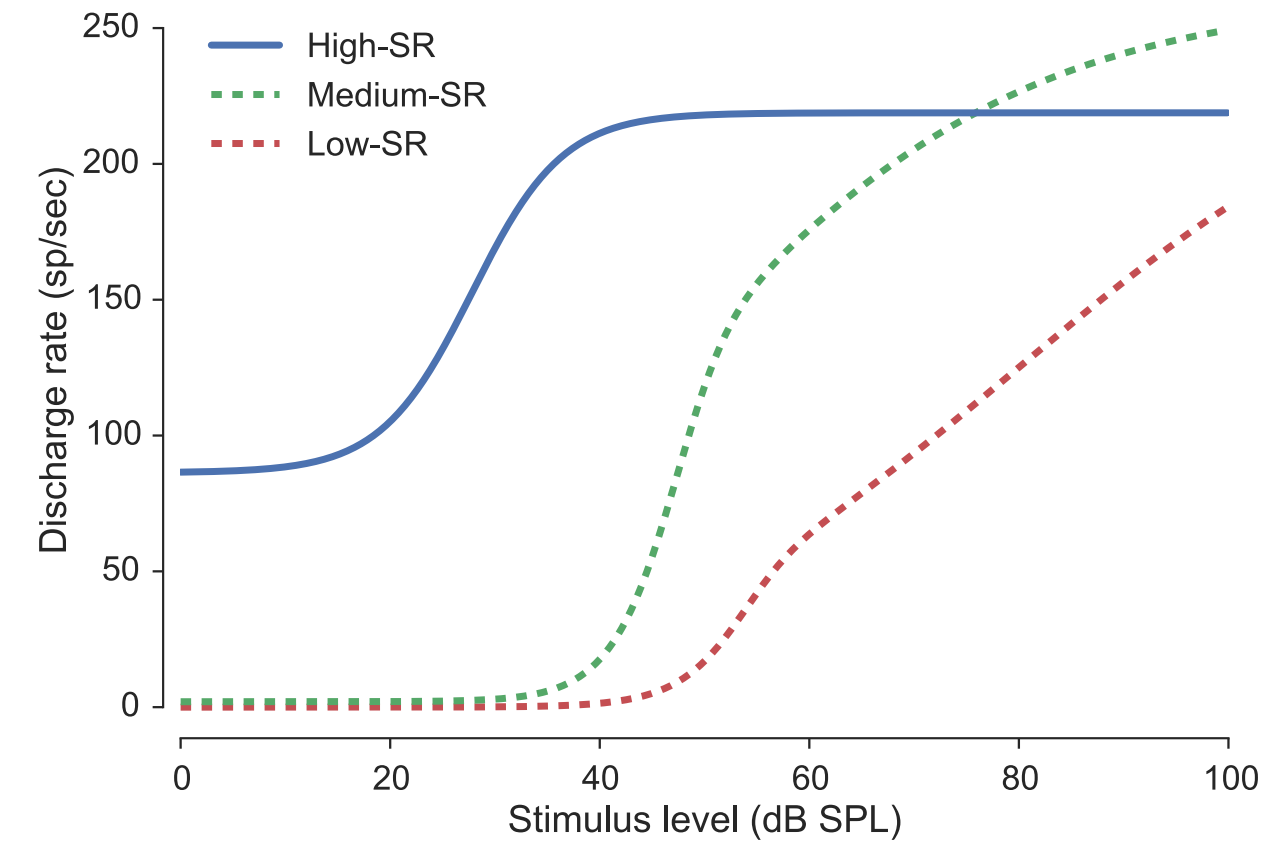
Potential explanation



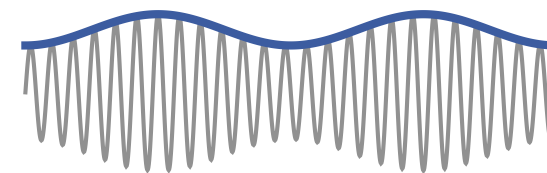
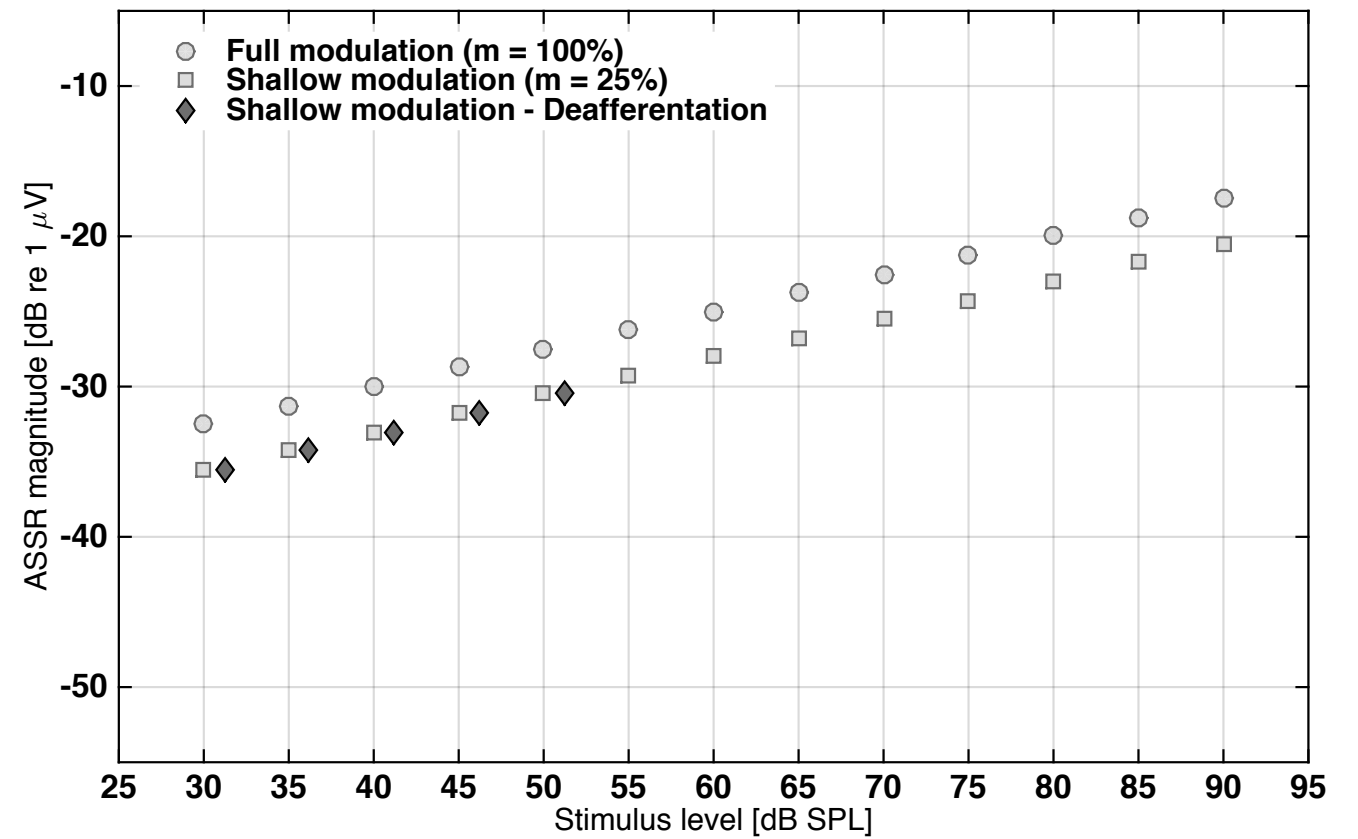
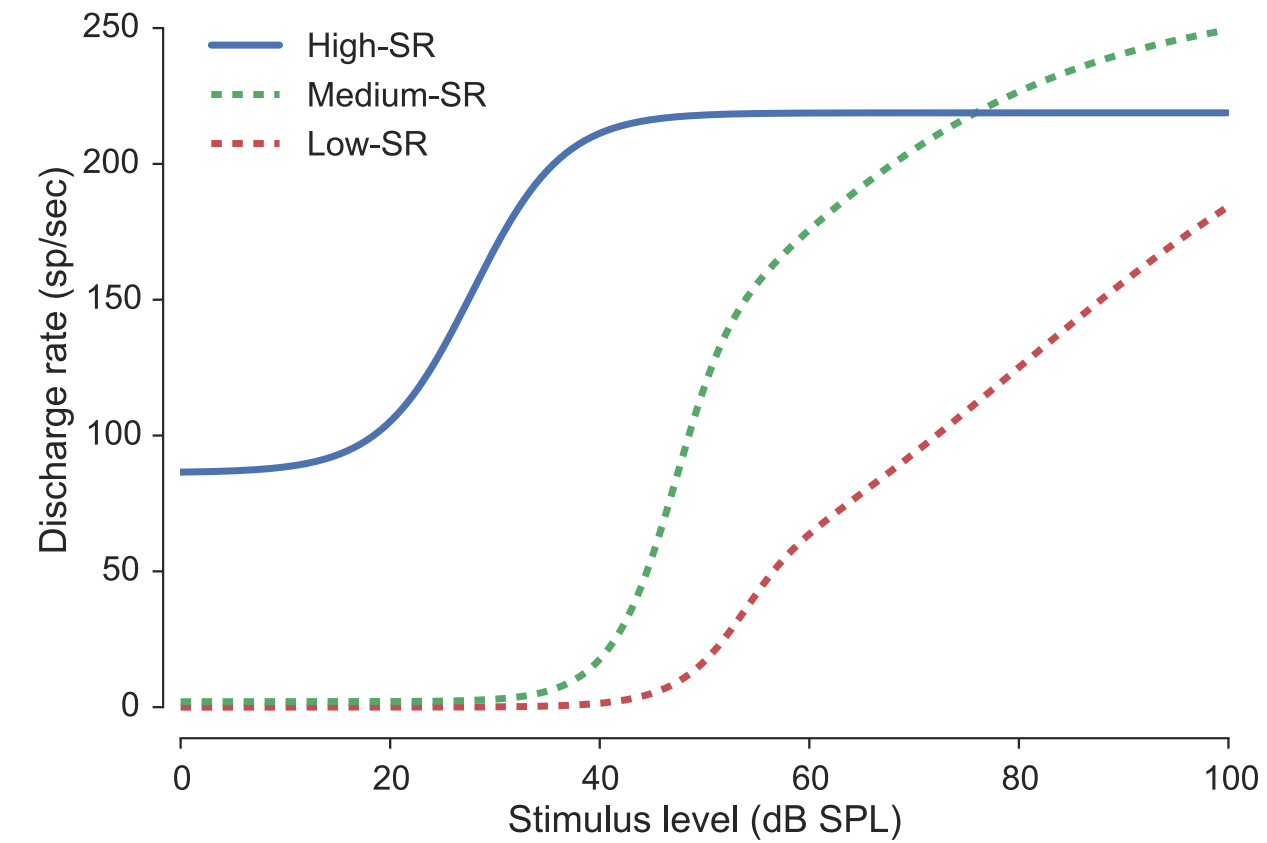
Potential explanation



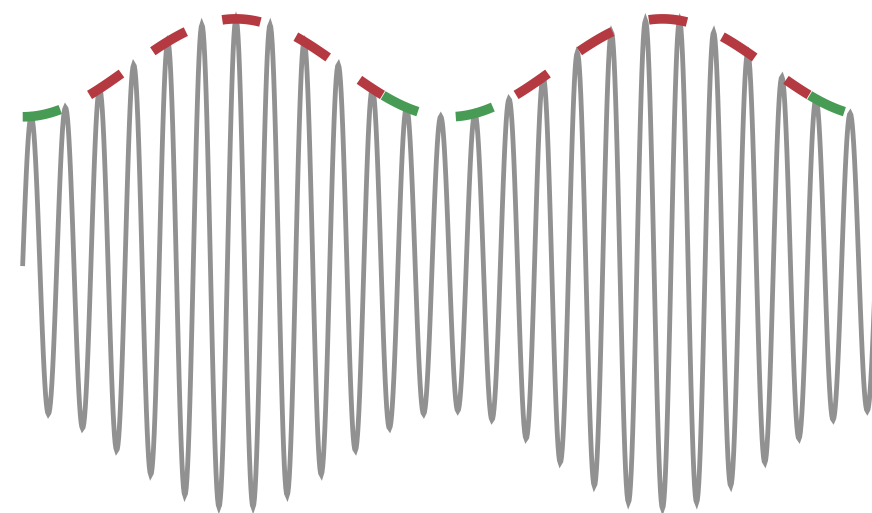
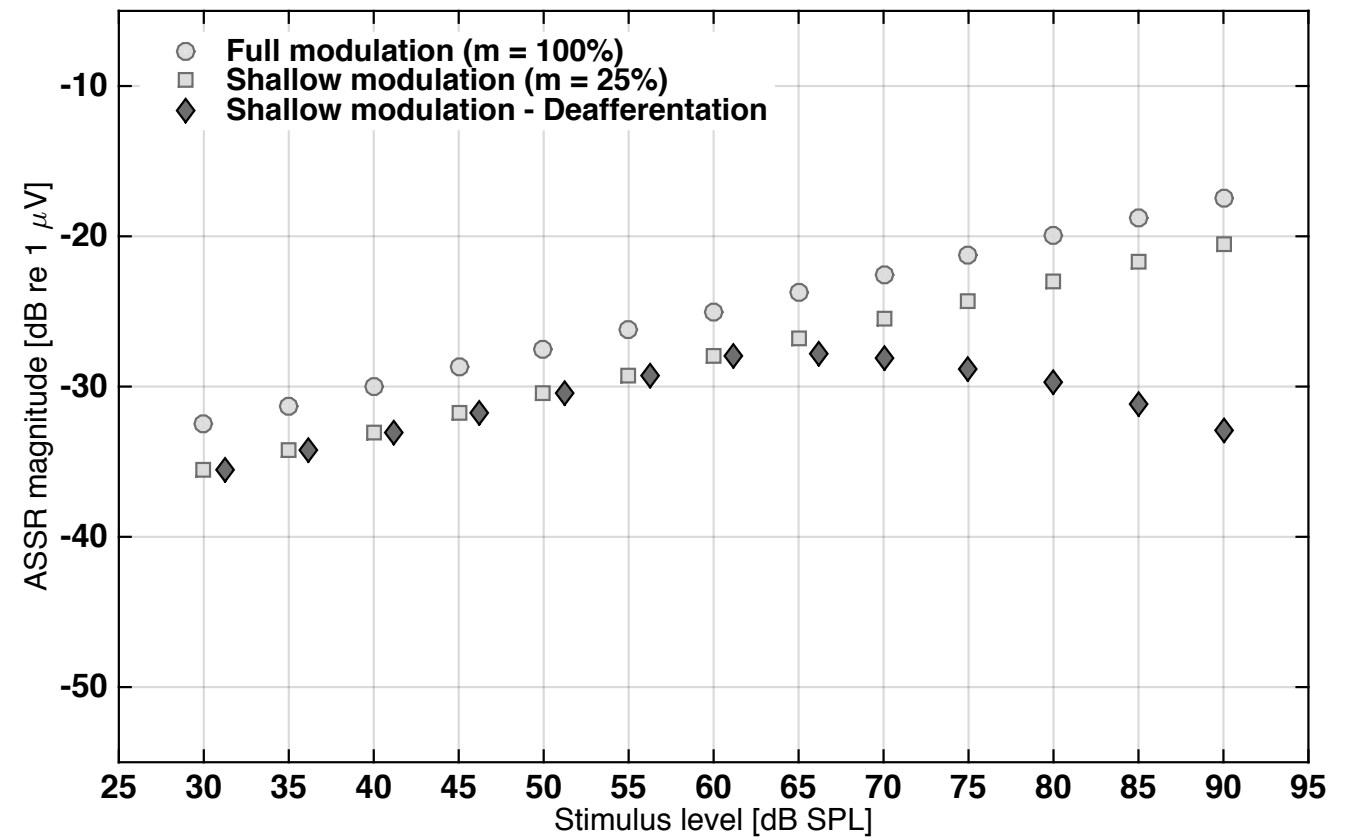
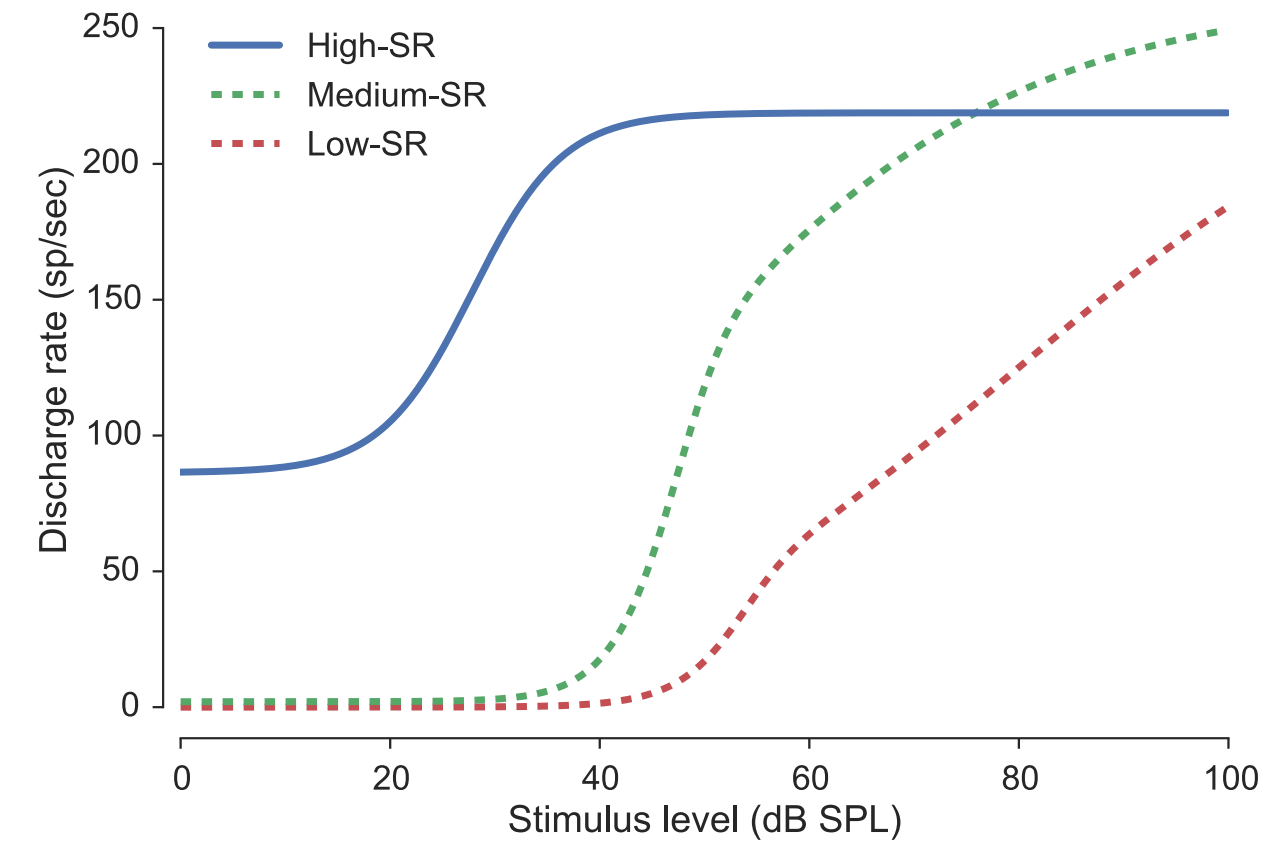
Potential explanation



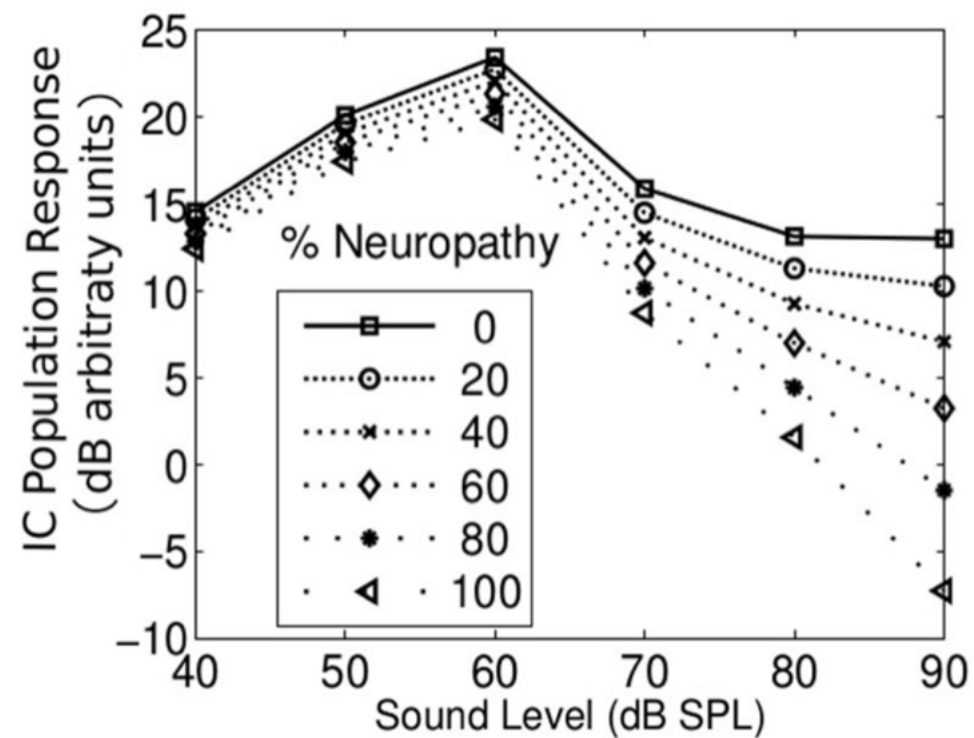
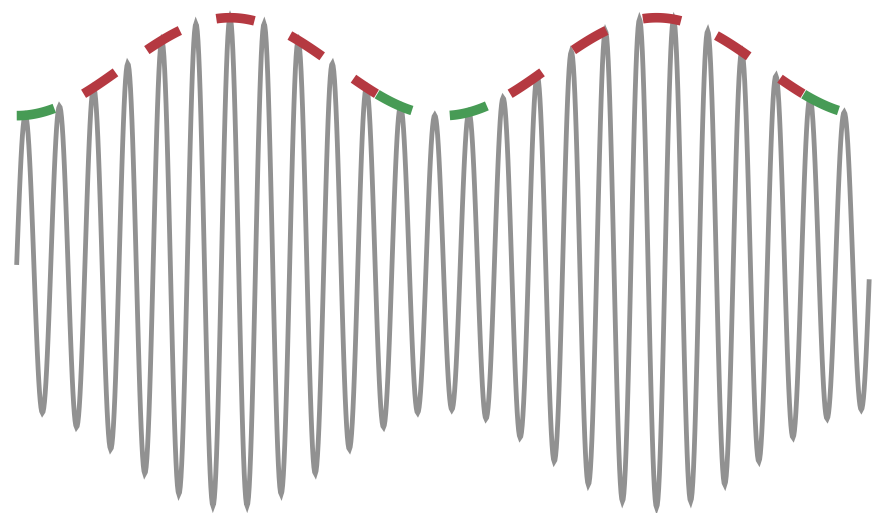
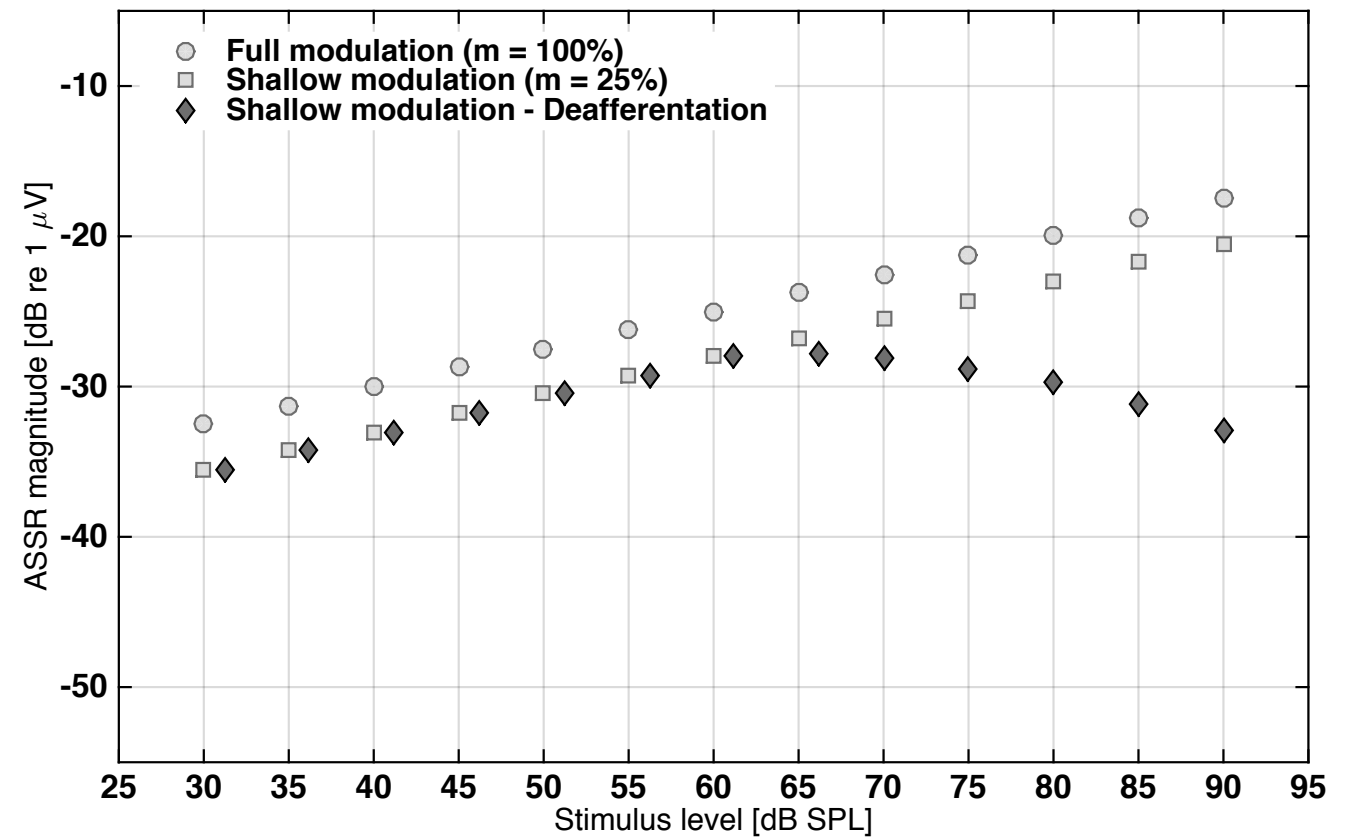
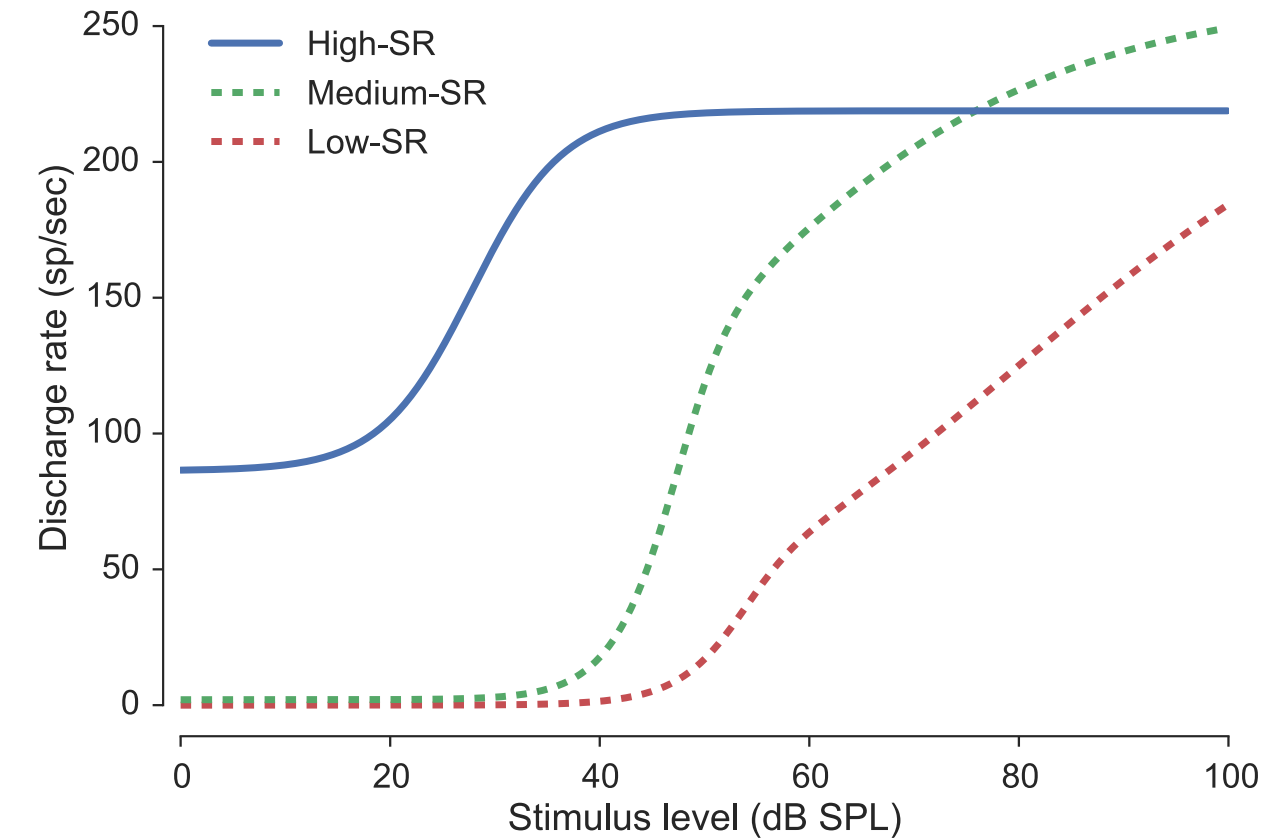
Potential explanation



Potential explanation



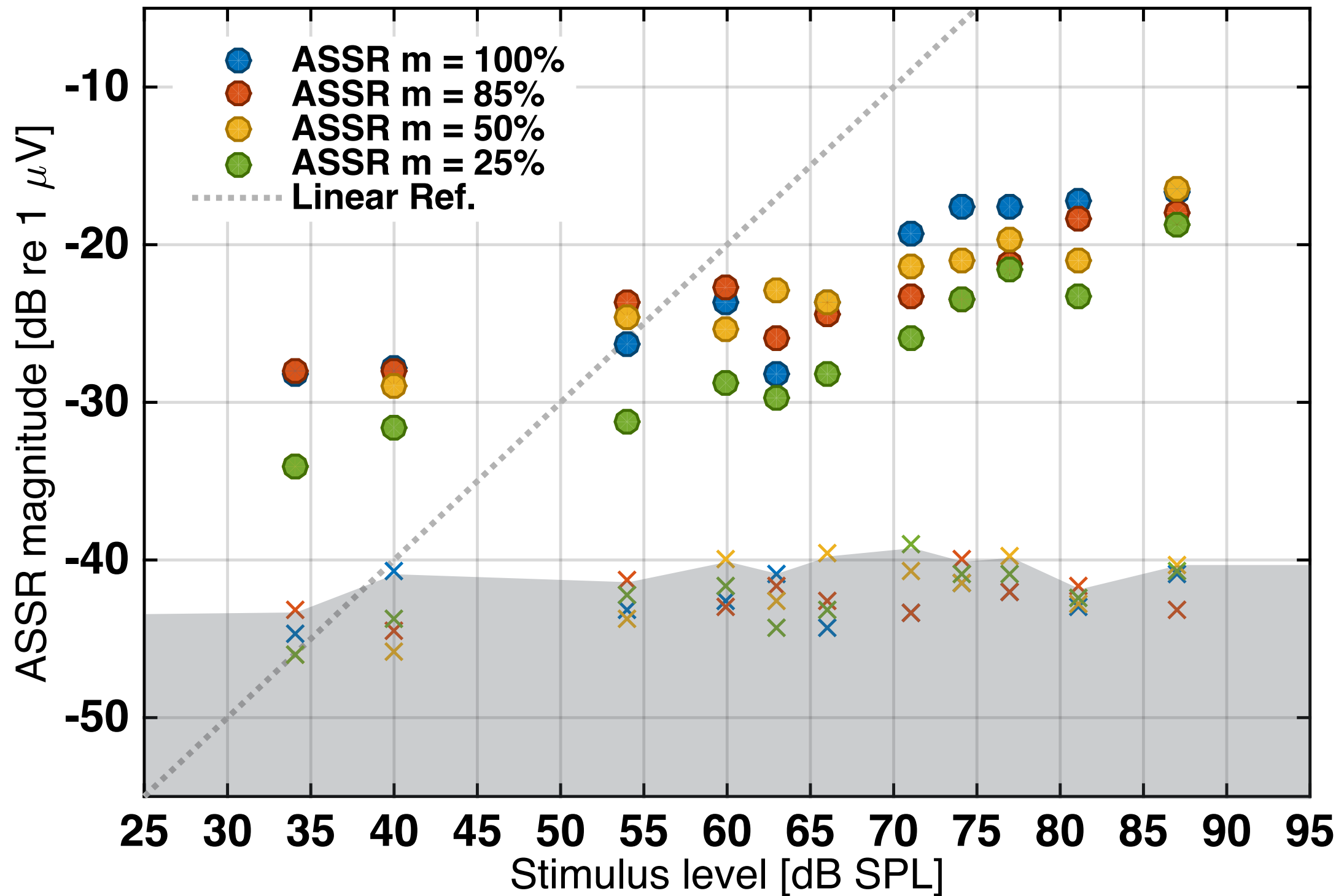
Potential explanation



Pilot results: Individual NH subjects

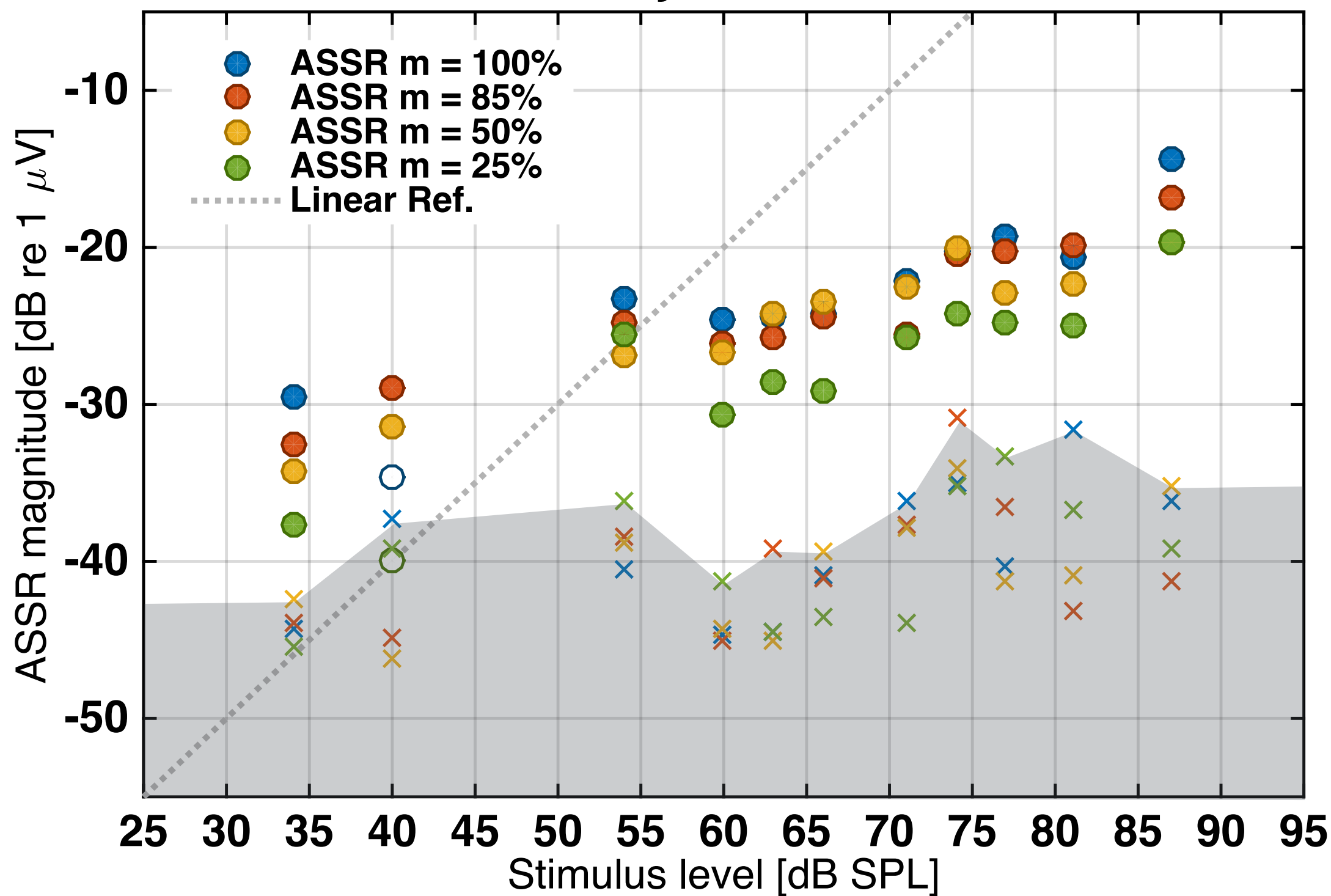
Pilot results: Individual NH subjects

Subject: APG



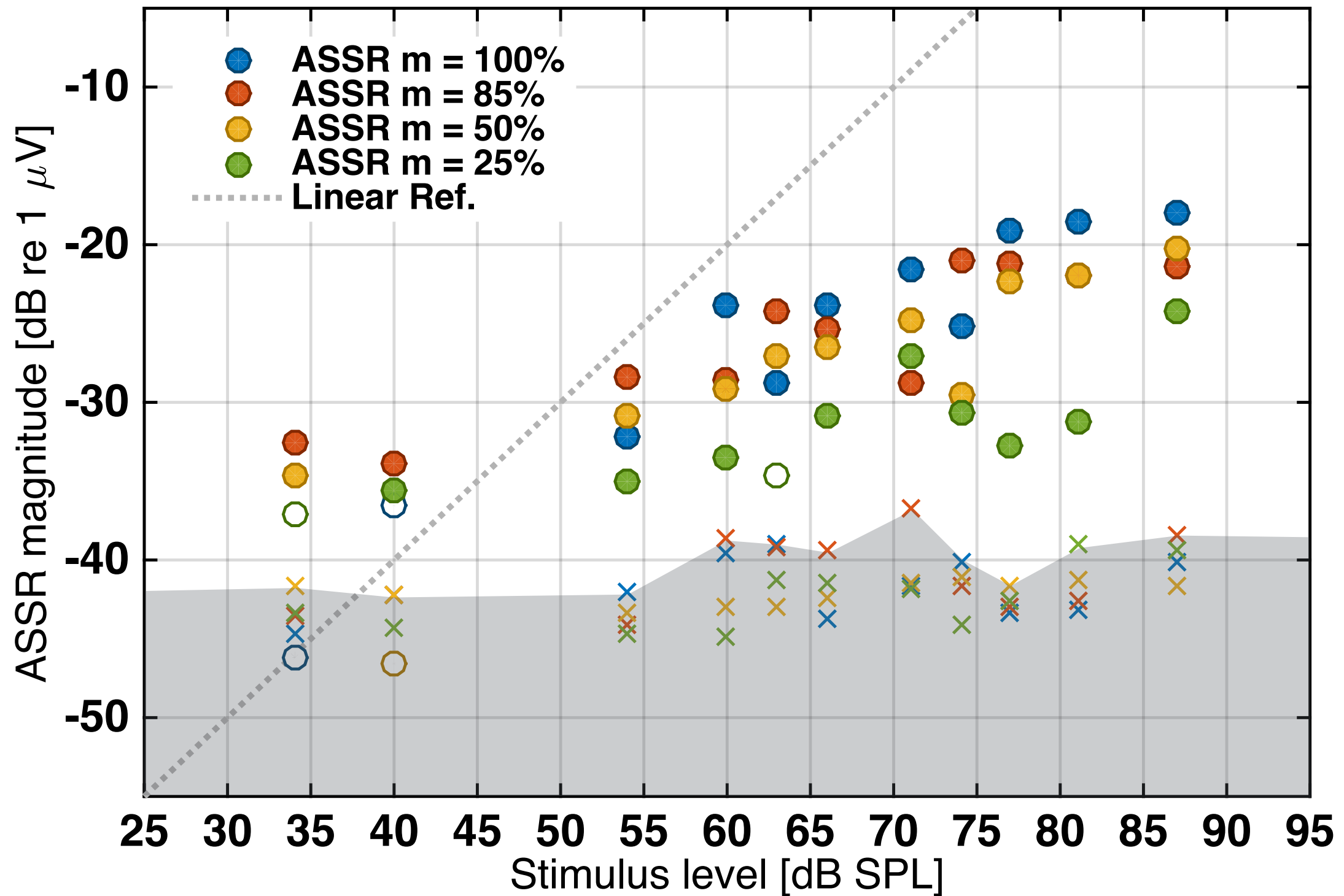
Pilot results: Individual NH subjects

Subject: KGS



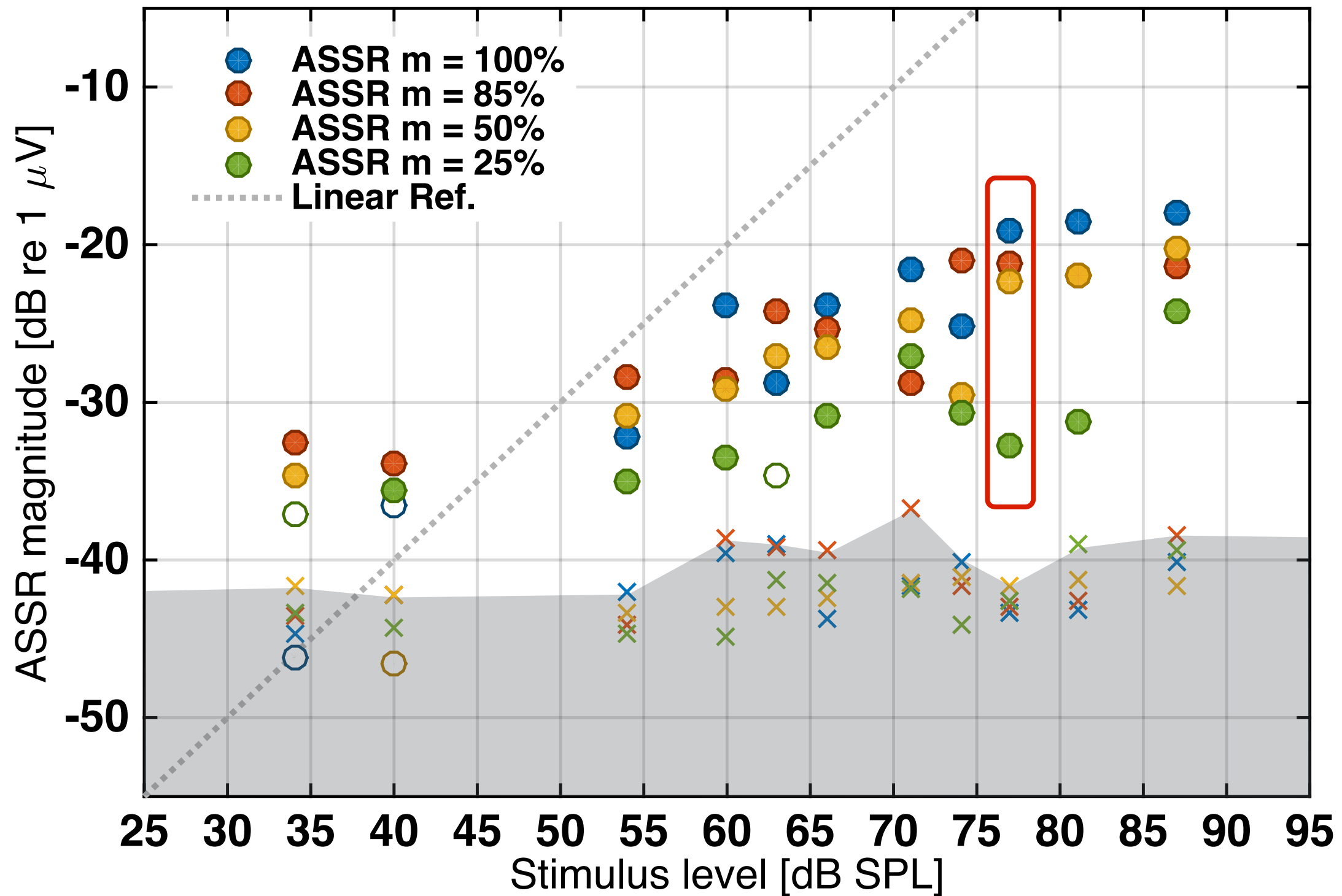
Pilot results: Individual NH subjects

Subject: IGC



Pilot results: Individual NH subjects

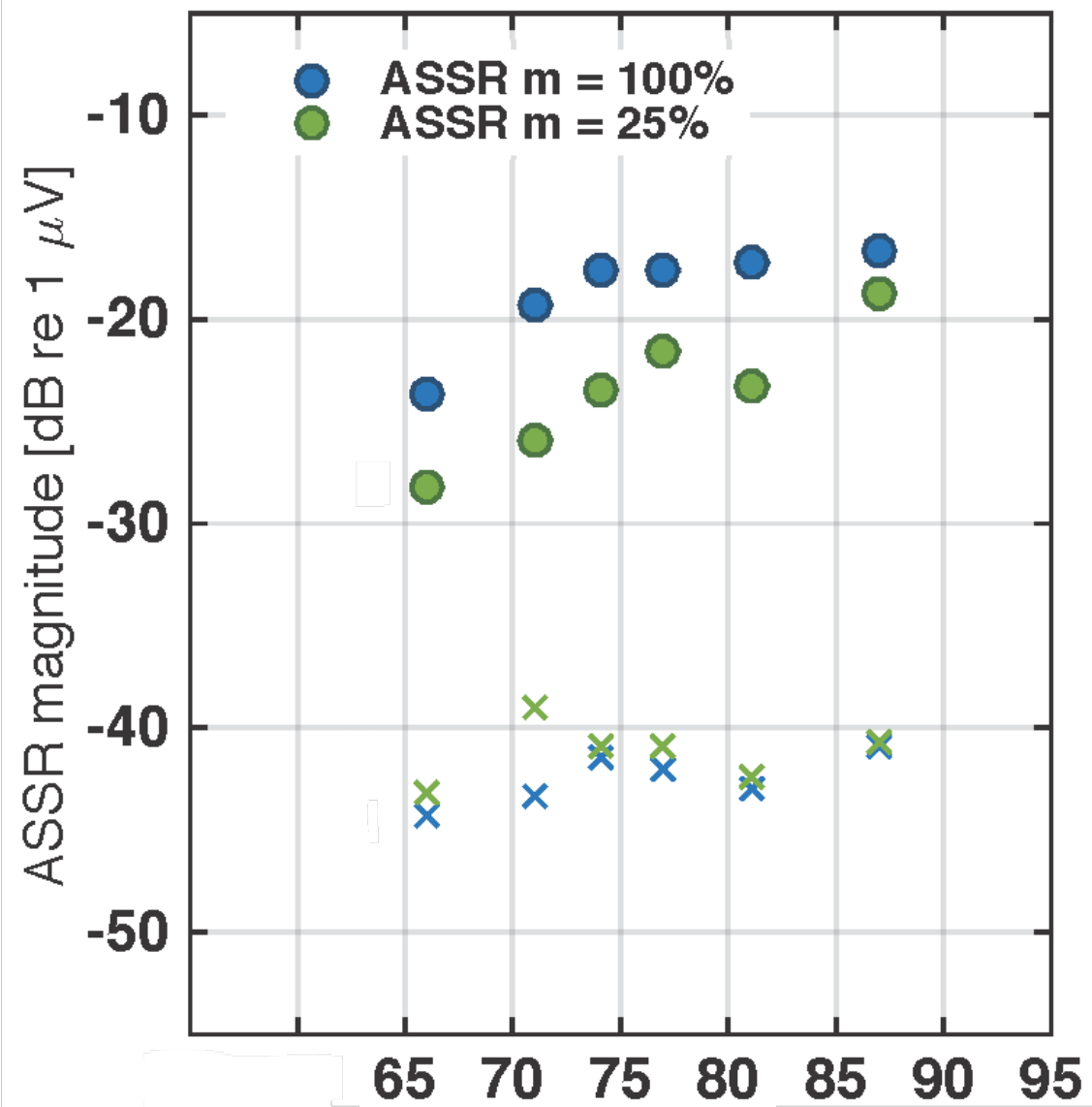
Subject: IGC



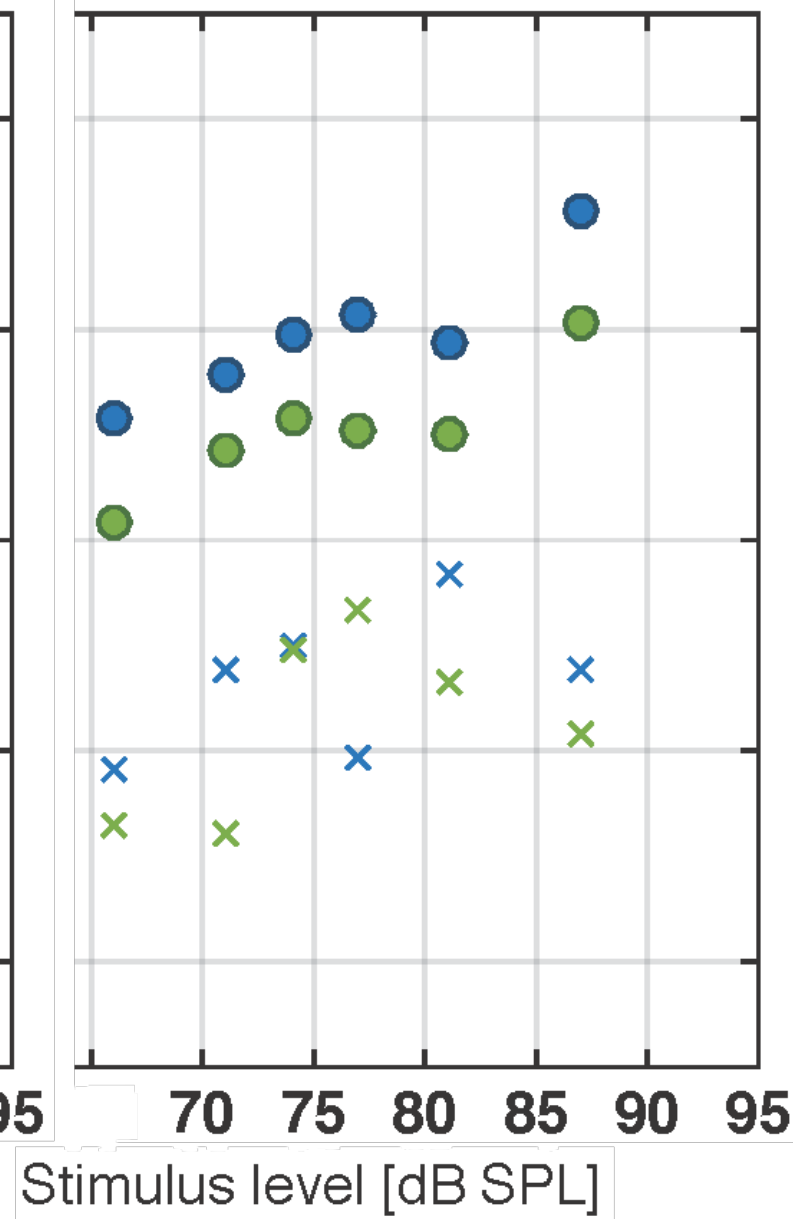
Pilot results: Individual NH subjects

Pilot results: Individual NH subjects

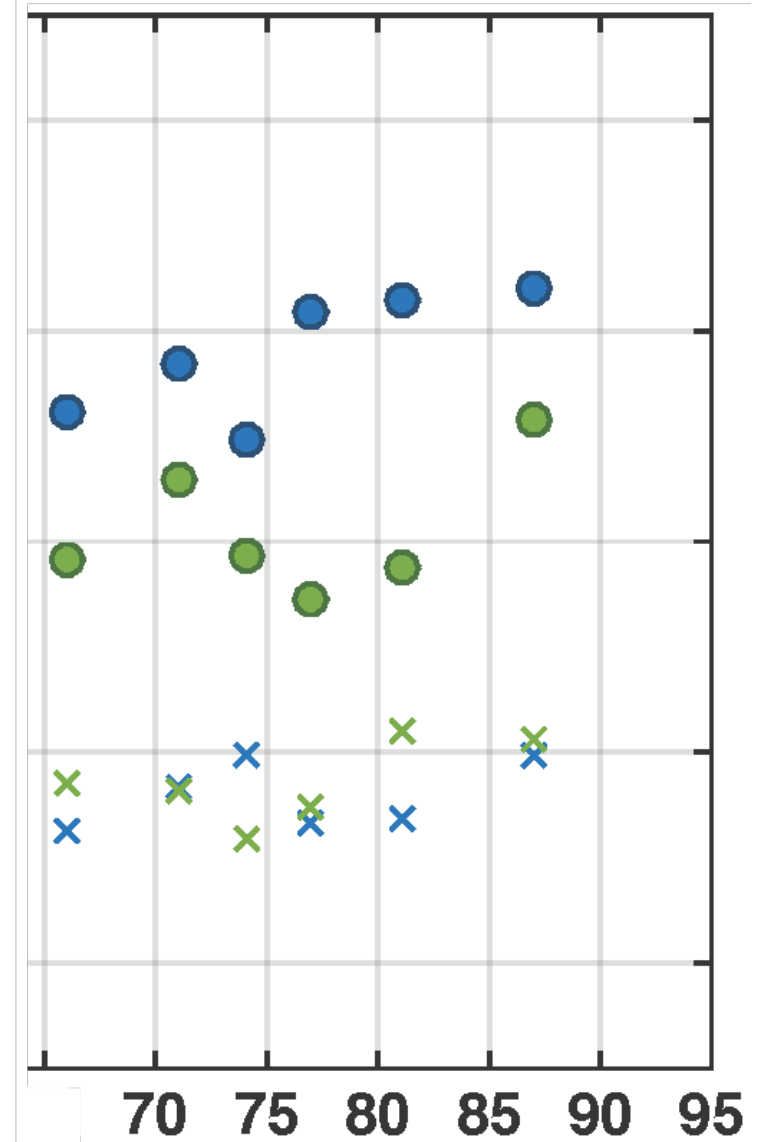
Subject: APG



Subject: KGS



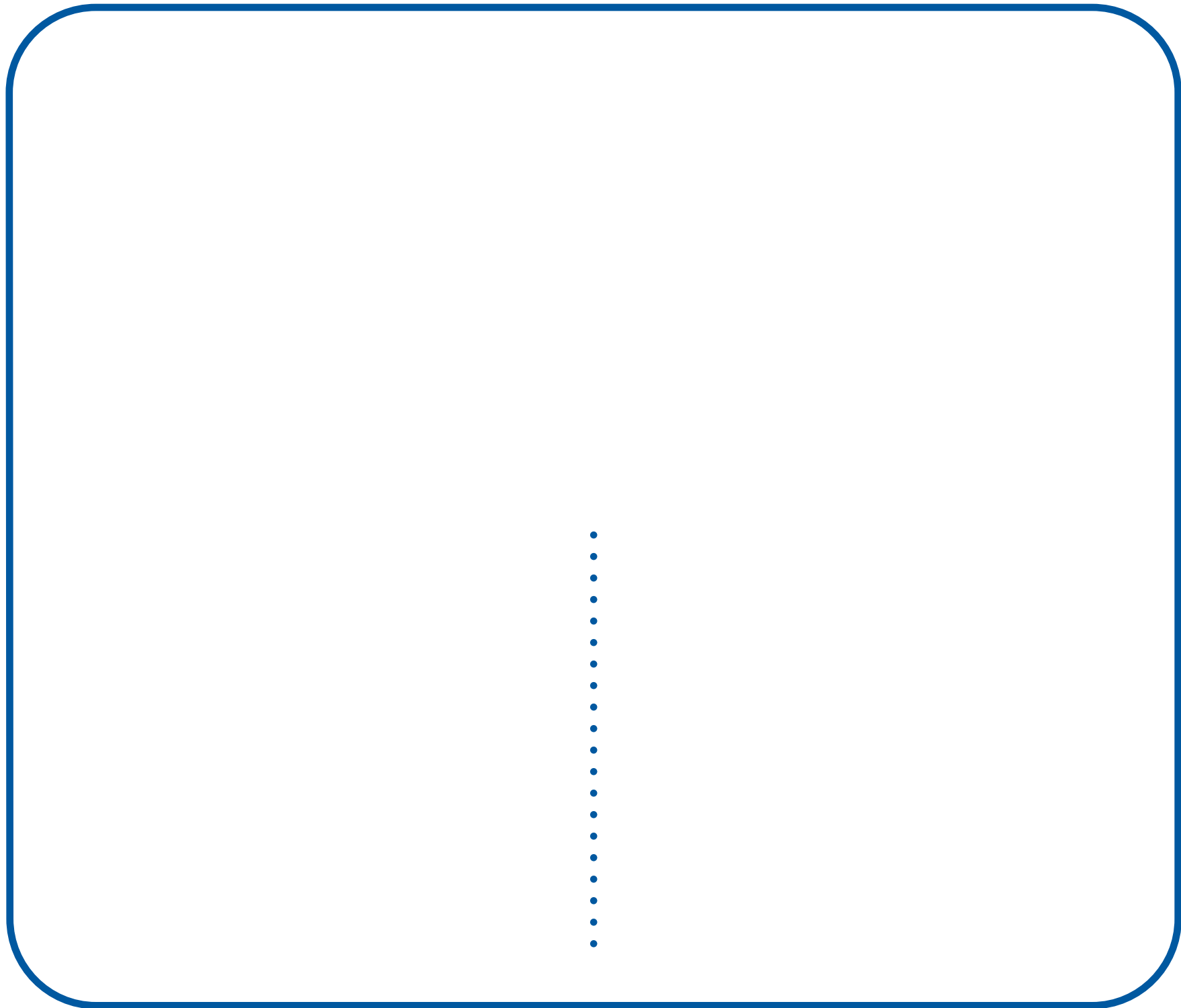
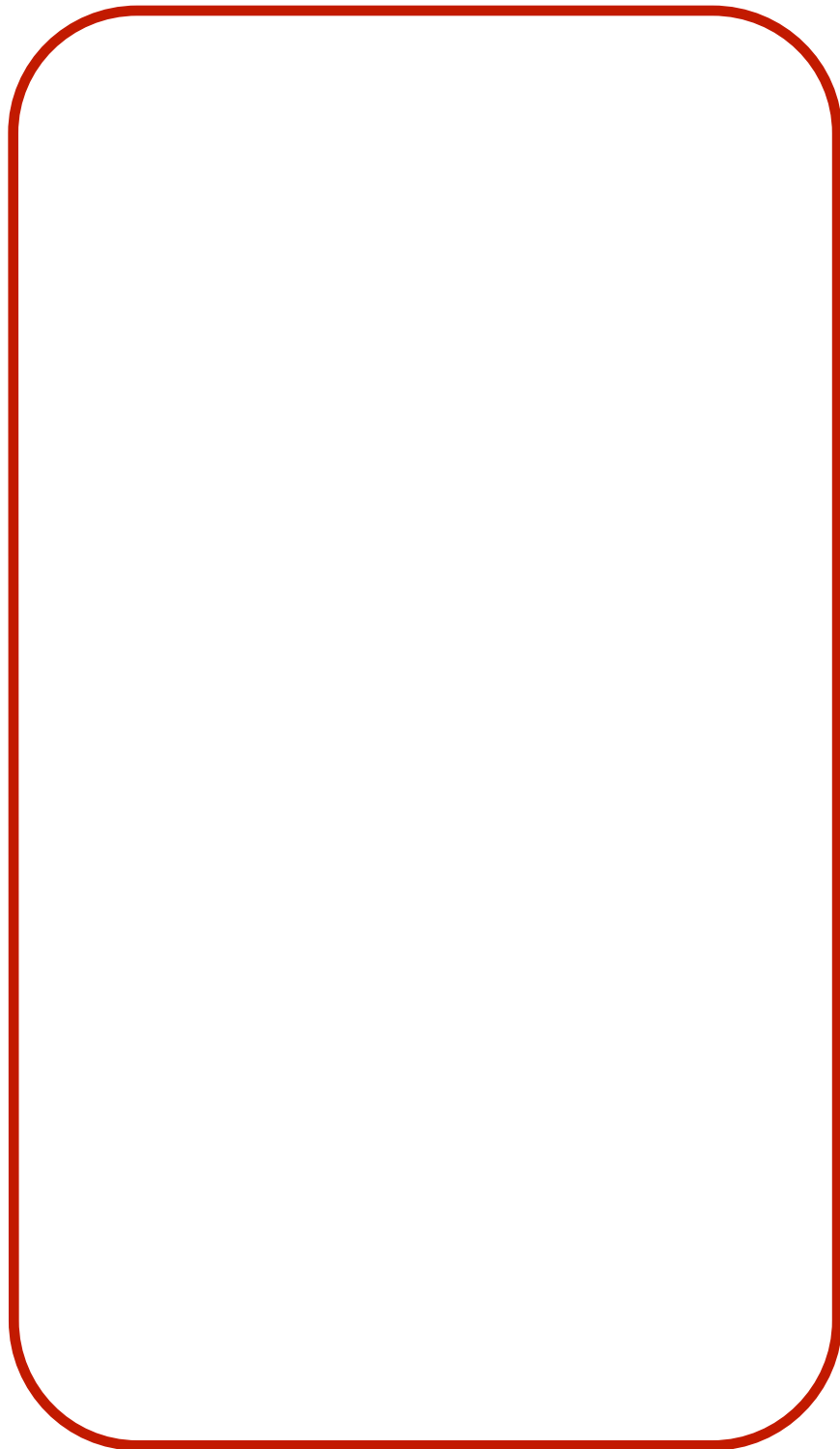
Subject: IGC



Stimulus level [dB SPL]

Next steps

Next steps



Low exposure NH



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Next steps

Low exposure NH



High exposure NH



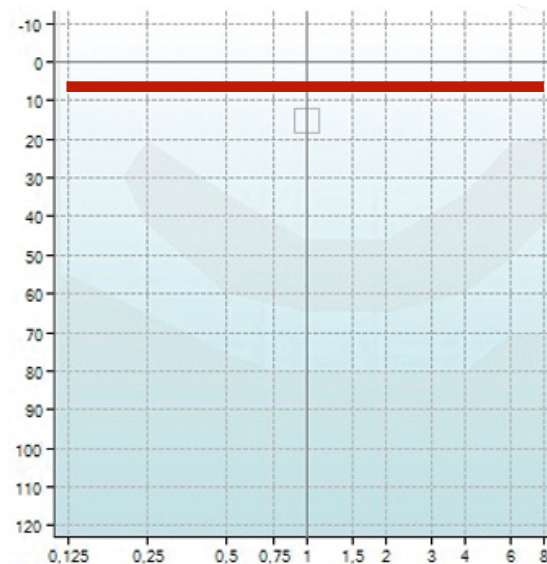
High exposure mild HI



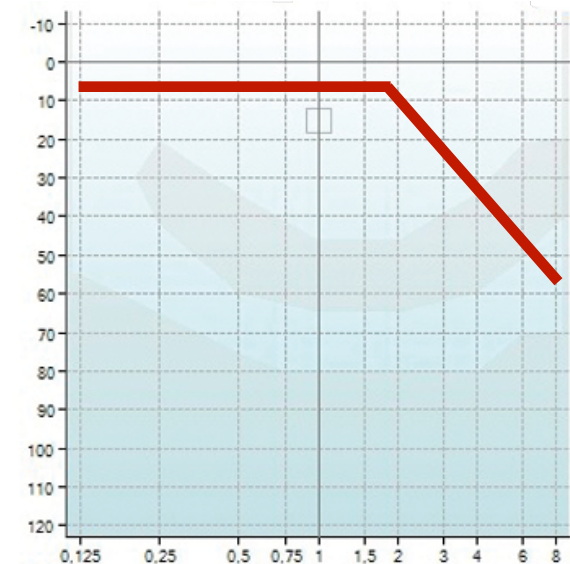
Low exposure NH



High exposure NH



High exposure mild HI



- ASSR are already used in the clinics to **estimate thresholds** objectively
- **ASSR growth functions** are suggested to be used as a tool to **assess compression** (and loss of compression) at different frequencies simultaneously
- We hypothesize that ASSR growth functions at higher stimulation levels using shallow modulations **reflect the integrity of ANFs**

Thank you!

Mange tak!

Moltes gràcies!